TAB 4

IN THE UNITED STATES DISTRICT COURT
FOR THE MIDDLE DISTRICT OF FLORIDA
ORLANDO DIVISION

MITSUBISHI HEAVY INDUSTRIES, LTD., Plaintiff,	)	
-vs-	)	No. 6:10-CV-00812-JA-GJK
GENERAL ELECTRIC CO., Defendant.	)	

Videotaped deposition of JULIE L. DAVIS taken before TRACY L. BLASZAK, CSR, CRR, and Notary Public, pursuant to the Federal Rules of Civil Procedure for the United States District Courts pertaining to the taking of depositions, at Suite 2150, 20 North Wacker Drive, in the City of Chicago, Cook County, Illinois at 9:20 a.m. on the 10th day of January, A.D., 2012.

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There were present at the taking of this deposition the following counsel:

IRELL & MANELLA LLP by
MS. MELISSA R. McCORMICK
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mmccormick@irell.com
(949) 760-0991

on behalf of the Plaintiff;

WEIL, GOTSHAL & MANGES LLP by
MR. ROBERT S. BEREZIN
767 Fifth Avenue
New York, New York 10153
robert.berezin@weil.com
(212) 310-8884

on behalf of the Defendant;

ALSO PRESENT: Mr. David Lender
Weil, Gotshal & Manges LLP;

Dr. Keith R. Ugone, Ph.D.;

Mr. Robert Zellner
Legal Videographer.

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VIDEOTAPED DEPOSITION OF
JULIE L. DAVIS

January 10, 2012

EXAMINATION BY:	PAGE
Ms. Melissa R. McCormick	5

* * * * * *

EXHIBITS

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* * * * * *

EXHIBIT PREVIOUSLY MARKED

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* * * * * *

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THE VIDEOGRAPHER: Good morning. We are going on the video record at 9:20 a.m. Today's date is January 10th, 2012.
My name is Robert Zellner, and I am a legal videographer in association with Merrill Legal Solutions.
The court reporter today is Tracy Blaszak.
Here begins the videotaped deposition of Julie L. Davis taken in the matter of Mitsubishi Heavy Industries, Ltd. vs. General Electric Company bearing civil action 6:10-CV-00812-JA-GJK in the United States District Court for the Middle District of Florida, Orlando Division.
This deposition is being held at 20 North Wacker Drive, Suite 2150, in Chicago, Illinois.
And will counsel please identify themselves for the record and state whom you represent starting with the noticing party.
MS. McCORMICK: Melissa McCormick, Irell & Manella, for Mitsubishi.
And with me today is Dr. Keith Ugone.
MR. BEREZIN: Robert Berezin, Weil, Gotshal & Manges, for General Electric and the witness.
THE VIDEOGRAPHER: Thank you.
And will the court reporter please swear in the

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witness.

JULIE L. DAVIS,

called as a witness herein, having been first duly sworn, was examined upon oral interrogatories and testified as follows:

EXAMINATION
by Ms. McCormick:

Q Good morning, Ms. Davis.
A Good morning.
Q Ms. Davis, you understand that you've just been placed under oath today just as if we were in court?
A I do.
Q And is there any reason that you can't give your best, most truthful, and most accurate testimony today?
A No.
Q Ms. Davis, how many times have you had your deposition taken before today?
A I don't have a specific number in mind. If we wanted to know precisely, we could count that on my CV. However, I would expect it would be somewhere between 150 and 200 times.
Q Did you do anything to prepare for your deposition today?
A I did.
Q What did you do?

Q Who is Mr. McGinniss?
A I understand him to be inside counsel at GE with responsibility for the area that brings us here today.
Q And when you say the area that brings us here today, do you mean wind turbine sales or do you mean something else?
A I'm thinking of wind turbines in terms of the accused products. It may be broader than that, but my focus was on this particular set of products.
Q And then, to your knowledge, is Mr. McGinniss also the inside lawyer who is responsible for seeing this lawsuit for GE?
A Yes, that's a fair characterization of my understanding.
Q Other than this phone conversation with Mr. Brzenzinski in December of 2011, have you talked with Mr. McGinniss on any other occasion about this case?
A Yes.
Q On how many occasions?
A I think there may have been two other phone calls with respect to this case specifically.
I had then also talked to him about the Texas case.
Q So how many conversations either on the phone or

in person have you had with Mr. McGinniss?
A Combining both Texas and Orlando cases?
Q And any other circumstances that you may have spoken to him?
A I have never spoken to him outside the context of these two cases. I believe there was at least one call in the Texas case that I had with Mr. McGinniss.
I believe there may have been other calls with GE employees where Mr. McGinniss was possibly on the phone or in the room with the GE personnel, but to my knowledge or my recollection, anyway, is that he was not participating in the discussions.
Q So as far as -- Strike that.
Have you ever met Mr. McGinniss in person?
A No, not to my knowledge.
Q So as far as telephone conversations with Mr. McGinniss where you were talking directly with him as opposed to him auditing or monitoring other conversations, I count four, is that correct, three in connection with this case and one in connection with the Dallas case?
MR. BEREZIN: Objection, form.
THE WITNESS: I would probably think of it as three, one with the Dallas case, two with this case, and then you may be counting a third one where he was on the

phone with Mr. Brzenzinski, but he was not the person doing the talking on that call.
MS. McCORMICK: Q All right. Let's focus on the two discussions with Mr. McGinniss about this case.
When did the first occur?
A I would anticipate both of those took place in December of 2011.
Q Your discussion with Mr. Brzenzinski that took place in December of 2011, did that discussion occur before or after your expert report was served?
A You talking about the one that I reference in my report?
Q Strike that. Let me ask you a better question.
The telephone conversation that you're referring to that you had with Mr. Brzenzinski in December of 2011, did that telephone conversation occur before you served your expert report, which is Deposition Exhibit 114?
A Yes, that's the one that I'm referencing in this report on page 4.
Q And other than that telephone conversation, you haven't spoken with Mr. Brzenzinski in connection with this case on any other occasion, is that right?
A I think that's correct. Certainly, not since the date of my report, anyway. I can't recall if there

were any prior to that, but I don't recall more than one right now.
Q So for purposes of trying to isolate the date of this conversation with Mr. Brzenzinski, because your report is dated December 9th, 2011, and you recall speaking with him in December of 2011, is it fair to say you think you talked to him sometime between December 1st and December 9th of 2011?
A Yes, unless it was the last few days of November. It was sometime between Thanksgiving and the date my report was submitted on the 9th.
Q All right. Let's focus back on the discussions with Mr. McGinniss, both calls in December of 2011.
Did those calls also take place sometime between Thanksgiving and December 9th?
A Yes.
Q Why did you talk to Mr. McGinnis?
A I wanted to cover two things with him, which was the subject of those two separate calls, one was to make sure I understood the importance of the ALC technology, or more specifically, the '185 patented technology in contrast to the '039 patented technology that's involved in most of the GE licenses.
The second reason I talked to him on the other call was to obtain information as to the number of

TAB 5

From: Woodhouse, Andrew J (GE Infra, Energy)
To: Schellings, Vincent (GE Infra, Energy)
CC: Rogge, Klaus (GE Infra, Energy); Schumacher, Guido (GE Infra, Energy)
Sent: 11/20/2006 5:42:59 PM
Subject: FW: Meeting with Airtricity - 15 Nov 2006

Vincent

With regard to the notes below, would it be possible to call you to discuss a possible two day session with Airtricity to present / discuss the 2.5xl.

They would like to visit Salzbergen, and include a tour of the factory, training centre and operations centre.

Also a visit to the prototype site if this was feasible.

They have a lot of questions regarding supply chain (UK based supply chain, commitments necessary to secure forward loading etc.), so would also like to take the opportunity to meet with our supply chain organisation.

A contingent of say 8 persons from Airtricity has been indicated.

Airtricity are a key Client and I believe this is a positive indication of their intentions regarding the 2.5 xl. They are targeting a meeting in December (2 nd week).

Best regards

Andy

-----Original Message-----
From: Woodhouse, Andrew J (GE Infra, Energy)
Sent: 20 November 2006 17:22
To: Maltepe, Mete (GE Infra, Energy); Schumacher, Guido (GE Infra, Energy); Schellings, Vincent (GE Infra, Energy); Rogge, Klaus (GE Infra, Energy); Kavafyan, Philippe (GE Infra, Energy)
Cc: Huxley, Richard (GE Infra, Energy); Furtado, Eustace (GE Infra, Energy); Moffitt, Steven P. (GE Infra, Energy)
Subject: Meeting with Airtricity - 15 Nov 2006

Brief notes from our meeting with Pamela Walsh:

2008 MOU Ireland

- Board Meeting this week for approval
- Final requirements: 50 x 1.5 s units and 7 x 1.5 se units
- Further discussion required between our respective wind teams regarding se v's s units for Knockastanna (5 units out of the 7 se's proposed). Agreed to go forward with se units at this stage.
- Airtricity requested that to mitigate their acquisition risk, could we include an option to allow them to ship units to France. We confirmed that flexibility could be provided in the MOU to give them an option of shipping the units to France rather than Ireland - we would need to check the implications of civil code laws on the contract, plus would need to include an option date for the grid and site specifics.
- GE to re-draft MOU with above quantities and "France" clause
- Agreed realistic timeframe to achieve MOU signature before 15 December

2008 US Volume Contract

- Target start date for converting volume order into a series of project contracts - End Q1 07
- Airtricity still unclear on how this would be handled - potentially in US with secondee from Dublin
- GE to staff accordingly

EXHIBIT
PENGAD 800-631-6989
9
Schumacher

Additional Units for US - 07/08

- Confirmed a potential additional 50 units available in Q4 07 at Munsville pricing levels and an additional 100 units in 2008 as a variation to the existing 08 volume contract
- They are interested, but have concerns regarding Nov/Dec delivery for 07 units to meet PTC
- On Munsville the project economics are very tight, and improve if they eliminate 3 or 4 units with the lowest capacity factors
- Cost of ZVRT remains an issue at 35K over the LVRT option, as they do not see this difference in the hardware

- Need to make sure that our message is consistent - their US office had been told that 100 units were now available in 07

09 US Volume Offer

- Pricing confirmed at 5% over 2008 contract pricing
- ZVRT would become part of standard scope (not optional) thus base price would be $1,710,000 plus 5%
- No additional cost for Canada option, but a robust drop dead date would be included
- End Jan / Feb 2007 a realistic target date for signature
- Initial offer would be for 300 units, but a larger quantity would be available if they require
- We have developed a standard regional transport pricing model and this would be included in our offer
- GE to submit formal offer this month
- Others are now releasing 09 pricing

- ZVRT still an issue - we suggested a meeting between the respective "experts" in the US. They accept that ZVRT is a requirement, but suggest that our LVRT with a little work / additional equipment would meet the requirements. They are not seeing the additional costs from others. They would welcome a meeting as soon as is possible.

2.5 MW Units

- Pamela suggested that the feedback given to Jim was unfortunate, as Martin had not been aware of the various hub heights that would be available (75 m HH would fit within the 125 m V90 tip height which is the basis of their Scottish consent applications)
- They were looking at the 2.5 MW seriously for projects in Europe.
- Agreed that they will send us wind data to check unit suitability on a selection of sites.
- Discussed a 2.5 MW teach-in at Salzbergen involving say 7 / 8 persons from Airtricity - potentially to include a visit to the Dutch prototype site. Target date 2nd week of December.

Arklow

- Airtricity understand that the 3.6MW technology will be orphaned, and are looking for GE to offer an extended lifetime support package to reflect this
- Without this support, finance will be difficult
- Support package to include availability guarantee

Operations (Graham Berry)

- Richfield - on-going issues with Scada and Battery Pack failure
- As agreed with Jim Nabors, Airtricity are drafting a partnership strategy document and plan to issue to GE this month - this will form the basis for a meeting in January
- GE need to nominate a single point of contact for all service issues in Europe
- Seamus Herron and Patrick Maquire will lead the Corneen end of warranty discussions for Airtricity (Advised details to Laurent Cambier)

GE Actions:

Re-draft 2008 MOU
Follow-up on additional 07 / 08 US units
Submit formal offer for 09 US volume
Arrange ZVRT meeting in the US (could broaden to include Greenville factory visit?)
Arrange 2.5 MW meeting in Salzbergen to be broadened into meeting with supply-chain, training centre and operations centre
GE to advise suitable service contact

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IGE Energy Services (UK) Limited

TAB 6

CONFIDENTIAL ATTORNEY'S EYES ONLY

IN THE UNITED STATES DISTRICT COURT
FOR THE NORTHERN DISTRICT OF TEXAS
DALLAS DIVISION

	§	
GENERAL ELECTRIC COMPANY,	§	
	§	
Plaintiff,	§	
	§	
v.	§	**Civil Action No. 3:10-CV-00276-F**
	§	
MITSUBISHI HEAVY INDUSTRIES,	§	**JURY TRIAL DEMANDED**
LTD., and MITSUBISHI POWER	§	
SYSTEMS AMERICAS, INC.,	§	
	§	
Defendants.	§	
	§	

OPENING EXPERT REPORT OF DR. W. MACK GRADY

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I. SCOPE OF ENGAGEMENT

1. I have been retained to give expert opinions and testimony related to the issue of infringement of U.S. Patent No. 7,629,705 ("the '705 patent"), including the background of the technology at issue, the design and operation of certain wind turbines made by Mitsubishi Heavy Industries, Ltd. and Mitsubishi Power Systems Americas, Inc. (collectively, "Mitsubishi"), and the design and operation of certain wind turbines made by General Electric Company ("GE").

2. This report sets forth my opinions and the bases for my opinions, including a summary and discussion of the '705 patent, the design and operation of the accused Mitsubishi wind turbines, and the design and operation of GE's wind turbines. My opinions are based on reviewing the '705 patent and file history, documentation and source code for the Mitsubishi wind turbines, documentation and source code for the GE wind turbines, deposition testimony, the claim constructions adopted by the Court and agreed to by GE and Mitsubishi, and public documents, including prior art, relating to the technology at issue. A list of materials I have considered is attached as Exhibit A. My study is ongoing, and I may supplement or amend these opinions based on the production of additional evidence, as a result of further analysis, or in rebuttal to positions taken by Mitsubishi. If I am asked to testify, I may provide demonstratives to aid in the presentation of my opinions.

3. I am being compensated for my time expended in connection with this case at the rate of $275 per hour. I have no financial stake in this litigation, and my compensation is not contingent upon the outcome of this litigation.

II. QUALIFICATIONS

4. My curriculum vitae is attached as Exhibit B.

5. I was born in Waco, Texas and was raised in the nearby town of Oglesby, Texas. I graduated with a B.S. in Electrical Engineering from the University of Texas, Arlington in

1971, and then went on to receive an M.S. in Electrical Engineering from Purdue University in 1973. From 1974 to 1980, I worked as a System Planning Engineer for Texas Power & Light Company (now Oncor) in Dallas. My responsibilities included transmission system planning in one of the four geographical divisions of Texas Power & Light. During that time I also served as chairman of the Dallas Chapter of the IEEE Power Engineering Society and as a member of the Edison Electric Institute Computer Committee.

6. I returned to Purdue and graduated with a Ph.D. in Electrical Engineering in 1983. I joined the faculty at the Department of Electrical and Computer Engineering, University of Texas, Austin in 1983 and have been there ever since. My current title is Professor and Jack S. Josey Centennial Professor in Energy Resources.

7. My areas of specialization are electric power systems, power quality and harmonics, renewable energy integration, power electronics, and synchrophasor applications in power grids. My present research funding comes from EPRI, Austin Energy, U.S. Dept. of Energy, Schweitzer Engineering Labs, and U.S. Dept. of Defense. I hold a security clearance through the DOD Defense Threat Reduction Agency to study the impact of high energy electromagnetic pulses (HEMP) on power grids. I recently participated in a week-long series of grid tests on this topic at the Idaho National Laboratory. I am also a regular technical advisor to the FBI on critical power system infrastructure issues.

8. I currently teach courses in power systems, power electronics, and renewable energy at U.T. Austin. In 2000, I was elected an IEEE fellow for "contributions in the analyses and control of power system harmonics and power quality." I received the annual Texas Execs Award for Outstanding Teacher in the College of Engineering twice. Other honors and awards

that I have received are listed in Exhibit B. I have been a Registered Professional Engineer in Texas (#48629) since 1981.

9. While my entire career has dealt with electric power systems, wind and solar integration in power grids has been the main focus of my research for the past four years. In particular, the emphasis has been on the use of synchrophasors as "health monitors" of grid stability so that more of the existing wind generator fleet in ERCOT can be utilized. My paper with David Costello of Schweitzer Engineering, "Implementation and Application of an Independent Texas Synchrophasor Network," describes the Texas Synchrophasor Network at U.T. Austin that was developed with EPRI and Schweitzer for the purpose of facilitating wind integration in ERCOT. A 100+ page summary report of our findings is on my web page, and I made presentations on this subject in the last twelve months at conferences sponsored by NREL, NASPI, UWIG, IEEE, and smaller audiences. One of the key contributions thus far is to illustrate with actual data that wind generation does not reduce ERCOT's grid inertia as commonly believed. The synchrophasor network will soon be expanded through EPRI in the Southwest Power Pool and Nebraska Public Power District. Again, the focus is on wind integration. In addition to synchrophasors, I work regularly with engineers at EON wind, ERCOT, and AEP wind where I visit wind farms to understand wind turbine operation, real-world issues, modeling, and simulation.

10. In 2010, I testified in court on behalf of the Texas Attorney General's Office in a case involving El Paso Electric. My testimony was to provide the judge with a description of how grids operate and to explain the role of power distribution equipment (e.g., distribution feeders, service drops, protection) and how it differs from transmission-level equipment.

III. PERSON OF ORDINARY SKILL IN THE ART

11. I expect to offer testimony regarding the level of ordinary skill in the art relevant to the '705 patent. It is my opinion that a person of ordinary skill in the art would have a bachelor's degree in Electrical Engineering with coursework completed (or equivalent experience) in electric power systems, electrical machines, power electronics, and renewable energy. In addition, the person of ordinary skill would also have two years of experience working with power electronics and/or electrical machines.

IV. TECHNICAL BACKGROUND

A. Basics of Electric Power

12. Electric power already accounts for about 50% of all energy used in the USA, and the percentage is growing. The convenience of simply "plugging in" to an electric outlet almost anywhere without need for liquid or gaseous fuel, storage, and pipes is a huge advantage. The 50% share will increase even faster as a sizable portion of automobiles gradually transition to plug-in hybrids.

13. Four scientific units are most important in describing electric power. These are voltage, current, power and energy. Voltage is the electrical potential difference between two points. Current is the rate of flow of electric charge through a medium. Power equals voltage times current. Energy equals power multiplied by elapsed time. Often these units of electricity are analogized to water flowing in a pipe. Voltage is analogous to water pressure (i.e., determines how quickly water can be delivered) and current is analogous to the rate of flow of water.

14. Essentially all electric power is made by turning a generator. In the case of coal, conventional natural gas, and nuclear, the heat source (combustion or nuclear reaction) creates high-temperature steam that turns a turbine attached directly to the shaft of a generator. For

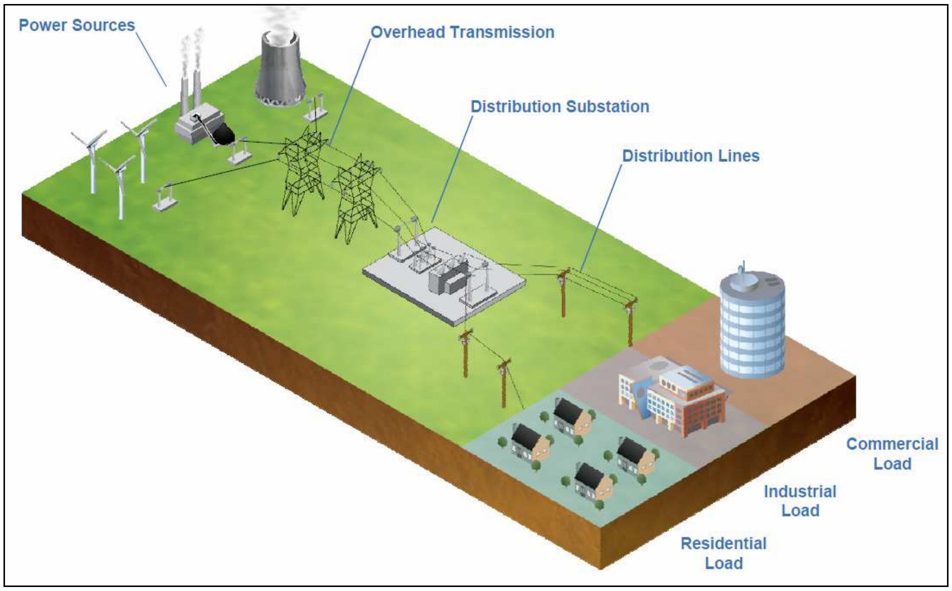
combustion turbines, superheated air flow from natural gas (or sometimes diesel) combustion turns a turbine attached to a generator through a speed-reducing gear box. For hydroelectric generation, moving water turns a turbine attached directly to the shaft of a generator. For wind generation, wind turns a rotor that is connected to a generator, usually through a speed-increasing gear box.

15. Almost all electric power produced is alternating current (AC), as opposed to direct current (DC). In alternating current the movement of electric charge periodically reverses, whereas in direct current the flow of current is only in one direction. The electric current delivered by power plants to homes across the United States has a frequency of 60 Hz, which means that current completes one full alternating cycle 60 times every second. Many other countries use a standard frequency of 50 Hz.

B. Electric Power System

16. An electrical grid (or power grid) is an interconnected network for delivering electricity from suppliers to consumers. A power grid generally consists of generating stations (e.g., nuclear, coal, wind, etc.), transmission lines for carrying electricity to centers of demand, and transformers that reduce voltage so distribution lines can carry electricity for final delivery to consumers. These elements are illustrated in the figure below. Due to the shear size of the United States, it is cost prohibitive to have only one massive electric grid. The United States is divided into three grids – Eastern, Western, and ERCOT (Texas).

CONFIDENTIAL ATTORNEY'S EYES ONLY



17. Most electric power is produced by large AC generating units in the 500 MW to 1000 MW range. AC has the advantage that transformers can efficiently change low voltage to high voltage, and vice-versa. Transmitting electricity at high voltages reduces losses over large distances. A large generator, such as 500 MW, typically produces 18-to-20 kV which is immediately stepped-up at the generating station to a much higher voltage such as 345 kV. On the receiving end, 345 kV is typically stepped down to 138 kV near cities, then to 12.5 kV inside cities, then finally to 240V/120V.

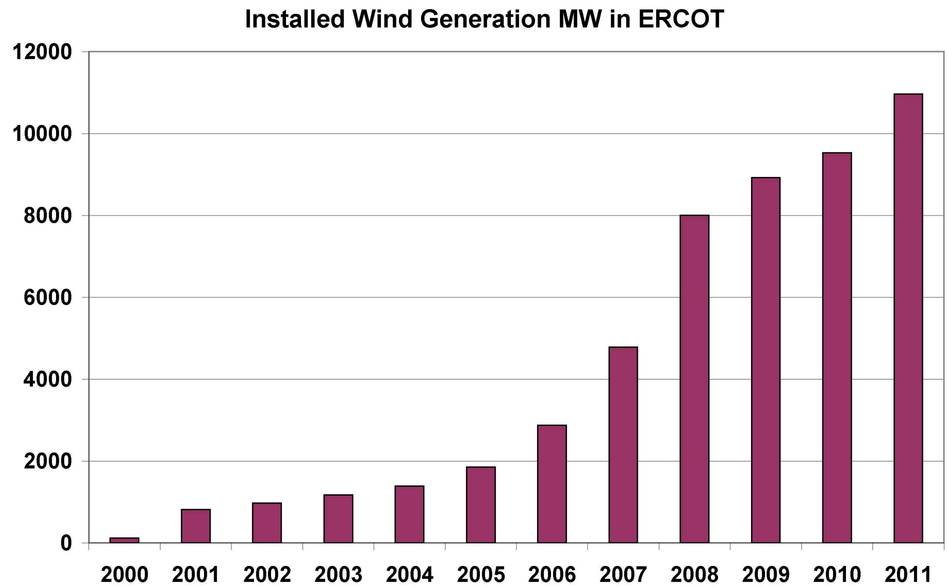
18. Three-phase electric power is the most common method of AC electric power generation, transmission and distribution. Three-phase AC has three separate phases, each separated by 120 degree phase angles. Nearly all AC generators larger than the simple home backup generators from hardware stores produce three-phase AC.

C. Wind Turbines

1. Background

19. As shown in the figure below, which was created by data provided by ERCOT, ten years ago ERCOT had less than 1,000 MW of wind generating capacity. Today the value is

11,000 MW, and GE 1.5 MW turbines represent approximately 43% of that total.[1]



To be economical, wind farms usually have at least 100 individual wind turbines located in successive rows. Most West Texas wind farms are on mesa tops, about 500 feet above the surrounding plains.

20. A modern wind turbine is composed of three basic parts- ***rotor blades*** attached to a ***nacelle***, which sits atop a ***tower***. The nacelle contains a rotor shaft connected to a generator, usually through a gearbox. There is also a transformer that connects the generator output to the underground distribution network of the wind farm.

21. All generators include a stator connected to the grid and a rotor connected to a source of rotational energy. The spinning of the rotor creates a voltage in the stator, and when connected to the grid, power from the rotor is transferred through the air gap to the stator and

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[1] I requested this information from John Moseley, an engineer at ERCOT, who is also a Ph.D. student at UT Austin. In mid-September, he provided me with a spreadsheet listing megawatts per wind turbine manufacturer for turbines installed in Texas.

then to the grid. Conventional synchronous generators (i.e., at coal, nuclear, and gas power plants) have a natural tendency to turn at grid synchronous speed (adjusted for the number of poles) when they are tightly connected to a grid. Most wind generators are asynchronous, which means that they do not have a tendency to turn at grid synchronous speed, and their rotor speed is allowed to vary so that maximum wind energy can be harvested.[2]

2. Asynchronous Generator Types

22. The GE 1.5 MW and Mitsubishi 2.4 MW wind turbines use a doubly-fed induction generator. The Mitsubishi 1.0 MW wind turbine (also called MWT-1000A) uses an induction generator. I have included a brief discussion of these generator types below.

23. Conventional three-phase induction machines are the workhorse of heavy industry throughout the world. They are simple, rugged, and long-lived. When unloaded a six-pole induction machine powered by 60 Hz will turn at 1200 RPM.[3] When a load such as a conveyor belt or compressor is driven by the machine, the machine slows down. At full load, it might slow down by 2% to 5% (e.g., 1175 RPM). This 25 RPM slow-down is known as slip, and currents induced in the rotor will have slip frequency. If too much load is applied, the machine enters an unstable region and stalls.

24. If the shaft of the same conventional induction machine is turned by an external force, such as wind, so that it rotates slightly faster than no-load (e.g., 1225 RPM), the machine will generate electric power. The graph below illustrates machine power and slip.

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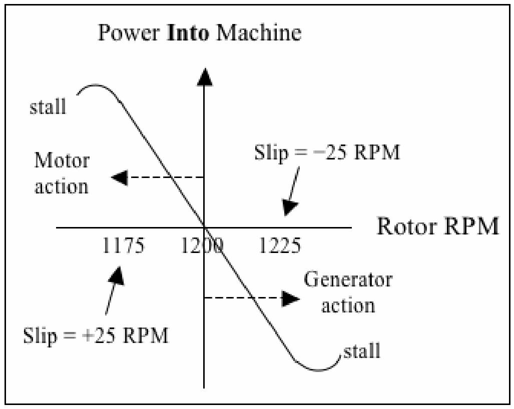
[2] This is consistent with the principle for maximizing wind harvest, which is mechanical rotor speed should be proportional to wind speed.

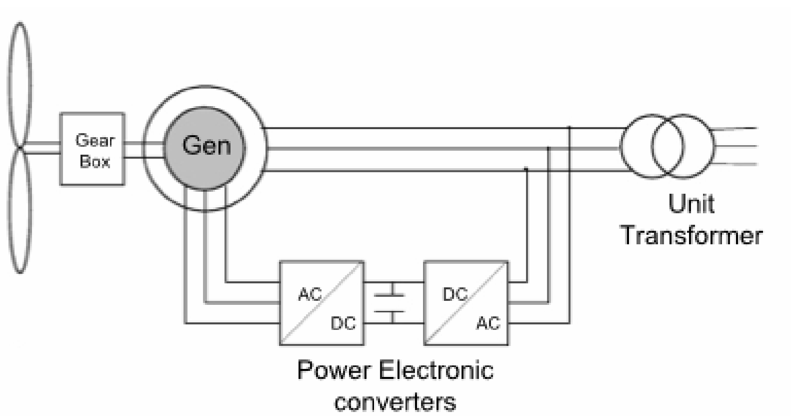
[3] In a three-phase machine, each set of stator windings creates two poles. An unloaded six-pole machine, powered by 60 Hz, yields a rotor speed of 1200 rpm, whereas a four-pole machine would yield 1800 rpm and a two-pole machine 3600 rpm.

CONFIDENTIAL ATTORNEY'S EYES ONLY



25. Induction machines are not well suited for wind generation because they typically operate in a tight 2-to-5% speed range, which is not compatible with the principle of wind turbine operation that turbine RPM should be proportional to wind speed. Because of this tight speed range, wind turbines using induction generators are commonly known as "fixed speed" wind turbines.

26. GE's 1.5 MW turbine and Mitsubishi's 2.4 MW turbine use a doubly-fed induction generator (DFIG), the topology of which is illustrated below. In a DFIG, the stator of the generator is directly connected to the grid. The rotor is connected to the rotor blade assembly through the gearbox. The rotor windings are also connected to a power conversion system. The power conversion system is composed of a grid-side converter and a rotor-side converter that are connected by a DC bus.



27. Unlike the induction machine discussed above, the DFIG permits true variable speed operation. To maintain steady state operation, the power conversion system injects current into the rotor that has frequency equal to the slip frequency.[4] By injecting current with the slip frequency in the rotor, the stator produces electricity at a frequency equal to the grid frequency, while at the same allowing the rotor speed to vary in proportion to wind speed.

28. In order to connect the stator of the DFIG to the grid, the rotor excitation current must be controlled so that stator voltage is synchronized with the grid voltage, which means having the same magnitude, frequency and phase. Attempting to connect the stator to the grid when unsynchronized would result in short-circuit currents, and to avoid damage the wind turbine would trip offline. If synchronism is lost during operation, the generator would experience high currents causing protective relays to trip.[5]

29. DFIGs provide the benefit of variable turbine RPM to maximize wind harvest without requiring full power conversion from AC generator to DC bus to AC grid. At rated conditions, about 30% of the power is generated in the rotor of a DFIG and flows through the power converters to the grid, while the remaining 70% is supplied directly by the stator of the DFIG. The power conversion system for a DFIG costs less than a full conversion system because the power conversion system only needs to convert approximately 30% of the total

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[4] Slip frequency = (Grid Frequency / No. of Pole Pairs) – Rotational Speed of the Rotor in Hz.

[5] Current flow from a wind generator depends on both voltage magnitude and phase angle. When synchronism is lost, the wind generator voltage magnitude may not change right away, but the phase angle rapidly drifts from that of the grid. The difference in phase angle creates very large currents that trip the protective equipment avoid damage. Furthermore, any sudden grid voltage magnitude decrease or increase (such as reconnecting the wind generator to the grid with a large phase angle difference) creates high transient voltages and currents in the wind generator due to the response of generator inductances.

generator power, but presents more difficult control problems, for example, in dealing with grid irregularities.

D. Grid Disturbances

30. It is common for disturbances to occur that cause fluctuations in the grid. The most common event of interest to wind farms is a classic voltage amplitude decrease due to a lightning-induced single-phase fault. Lightning hits a tower, the overhead static wire, or one of the phase wires on a three-phase transmission line, arcs to the tower and ground, which drives the voltage on that phase wire down. The net effect of this of type of disturbance is the wind turbine will see a voltage amplitude decrease on one or two phases of the grid. The lightning strike is over in less than 1 cycle[6], but the arc would continue indefinitely if substation circuit breakers on both ends of the line do not open to clear the fault properly. Breaker opening takes approximately 3-to-6 cycles, then there is a 20-cycle waiting period so that the fault most likely clears, then the breakers re-close. If a fault is not cleared properly by circuit breakers on the ends of the faulted line, then after some delay, the breakers "one bus back" take action, opening their transmission lines to attempt to isolate the fault. If the second group of breakers fail, then there may be a third level, but at that point a regional blackout or even grid islanding may occur.

31. During the fault, the voltage decrease is most severe at the faulted point. As you move away from the faulted point, the voltage gradually rises. For example, a location approximately 100 miles away from the faulted point will see essentially no voltage decrease. Whereas locations approximately 1 mile and 10 miles from the faulted point may experience a voltage decrease down to approximately 0.2 pu and 0.8 pu, respectively.

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[6] 1 cycle at 60 Hz is approximately 0.016 seconds.

32. The next most common fault type is phase-to-phase, including phase-to-phase-to ground. These can be induced by a lightning strike that "splashes" over more than one phase and creates an arc. As far as severity, a phase-to-phase is similar in nature to a single-phase fault.

33. The most severe fault is a three-phase fault. Single phase and phase-to-phase faults can degenerate into three-phase faults during the violent arcing period. Three-phase faults are commonly used as the "worst case" scenario for calculation and simulation purposes. A three-phase fault relatively close to a wind farm substation can create a voltage decrease down to zero volts, where the wind turbines at the farm are unable to observe the grid. When the grid is not observable, the sophisticated control system on DFIGs no longer have the grid voltage reference needed to determine slip frequency and phase angle information. That information is required to inject the appropriate rotor excitation currents in order to maintain synchronism with the grid. The loss of synchronism can result in an immediate trip of the turbine when the grid recovers from the zero voltage event.

E. Wind Turbine Response to Grid Disturbances

34. Wind turbines are particularly susceptible to grid disturbances. First, the power electronics utilized in modern wind turbines can be damaged by transient overvoltages caused by sudden voltage decreases on the grid. For example, a voltage decrease will create excessive currents in a DFIG generator rotor, which then increase the voltage on the DC bus, possibly damaging the power converter. Second, a voltage decrease on the grid forces the power output of the generator to drop while the wind force is unchanged, thereby causing a rapid acceleration of the blades and possible gearbox and other damage to the wind turbine. Uncontrolled acceleration of the blades could easily result in the destruction of the wind turbine. Third, wind turbines, as explained earlier, require complex controls to maintain synchronization with the

grid. Loss of grid visibility can prevent synchronism, and result in the wind turbine tripping offline.[7]

35. The conventional response of older wind turbines to a voltage decrease was to trip offline. This was an acceptable response when wind turbines were not a large portion of power generation. But as the percentage of wind turbines increased, the prospects of having entire wind farms tripping offline due to voltage drops became a grid issue (as opposed to simply a wind farm operator issue). Wind farms tend to be concentrated in sparsely populated geographic regions where the grid is relatively weak. If an entire farm trips offline, the surrounding region is likely to experience a large voltage drop, with the possibility of the voltage falling below the nominal 0.90 to 1.05 per unit voltage range. Because of the lost generation, it will also be necessary to either make up or import power to cover the regional loss. From the point of view of the wind farm owner, a whole-farm trip is a major event that causes loss of generating revenue and the possibility of damage to one or more the turbines as a result of the trip.

36. Because of these grid impacts, grid operators responded by promulgating requirements that wind turbines remain connected to the grid during voltage decreases of a certain duration. Initially, grid operators issued new requirements in the grid codes that a wind turbine must remain connected to the power grid during events when the grid voltage drops as low as 15% of nominal for brief periods at the point of interconnection. The objective of "ride through" requirements is to prevent widespread tripping of wind turbines and farms when they

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[7] The phrase "tripping offline" is used to describe an event when a wind turbine generator is intentionally disconnected from the grid by either protective equipment or a manual command. Tripping offline causes a significant mechanical shock to the wind turbine.

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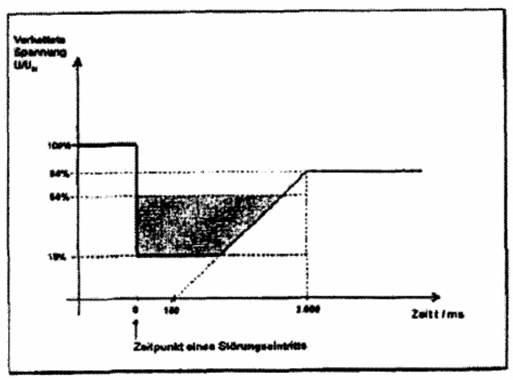
experience certain types of grid faults. The grid codes do not address how this capability is to be achieved.

37. The ability to remain connected to the grid during such low voltage events is often referred to as Low Voltage Ride Through (LVRT). The figure below illustrates an LVRT requirement set forth by E.ON in December 2001.



38. The technology necessary to accomplish LVRT has included inserting equipment that protects sensitive electronic equipment from voltage spikes without immediately tripping the turbine offline and enhancing the pitch control system to reduce the acceleration of the blades caused by a voltage decrease.

39. Grid codes have since evolved to include an even stricter requirement that a wind turbine remain connected to the grid when the grid voltage drops to zero. This special case of ride-through has been referred to as Zero Voltage Ride Through (ZVRT). An example of this type of requirement is found in the ERCOT Operating Guide at Section 3.1.4.6.1 (November 1, 2009).[8] For all wind turbines installed that were subject to an interconnection agreement signed after November 1, 2008, ERCOT requires the following:

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[8] ERCOT stands for Electric Reliability Council of Texas. ERCOT manages the flow of electric power to approximately 23 million customers in Texas (www.ercot.com/about/profile).

> "WGR [wind-powered generation resource] voltage relays shall be set to remain interconnected during three-phase faults on the transmission system for a voltage level as low as zero volts with a duration no more than nine (9) cycles as measured at the point of interconnection as shown in Figure 1. The clearing time requirement for a three-phase fault will be specific to the generating plant point of interconnection, as determined by and documented by the transmission provider in conjunction with the interconnection agreement. This requirement does not apply to faults that would occur between the generator terminals and the transmission voltage side of the generation step-up transformer or when clearing the fault effectively disconnects the generator from the system."

Figure 1 from the ERCOT Operating Guide that illustrates the voltage ride-through boundaries for wind turbines is reproduced below:

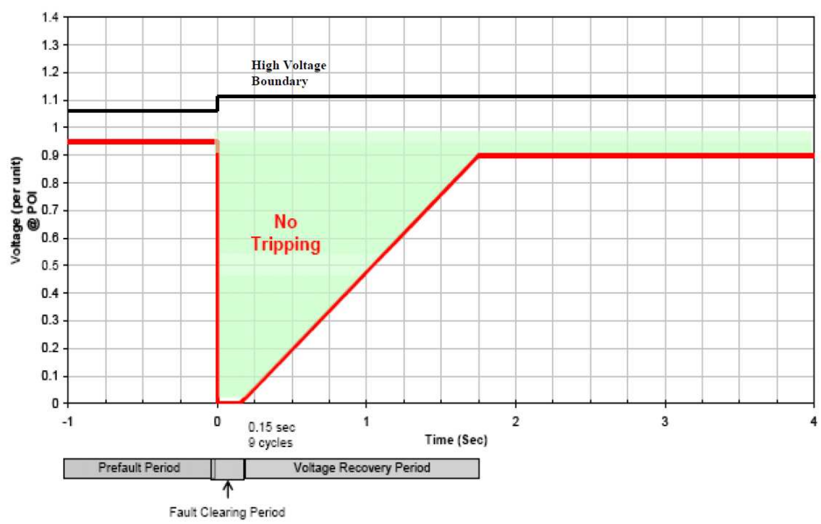

Figure 1: Voltage Ride-Through Boundaries For Wind-powered Generation Resources

40. The Federal Energy Regulatory Commission (FERC) has also issued a regulation requiring zero voltage ride through in the United States. FERC requires the following:

> "Wind generating plants are required to remain in-service during three-phase faults with normal clearing (which is a time period of approximately 4 – 9 cycles) and single line to ground faults with delayed clearing, and subsequent post-fault voltage recovery to prefault voltage unless clearing the fault effectively disconnects the generator from the system. The clearing time requirement for a three-phase fault will be specific to the wind generating plant substation location, as determined by and documented by the transmission provider. The maximum clearing time the wind generating plant shall be required to withstand for a three-phase fault shall be 9 cycles after which, if the fault remains following the location-specific normal clearing time for three-phase faults, the wind generating

> plant may disconnect from the transmission system. A wind generating plant shall remain interconnected during such a fault on the transmission system for a voltage level as low as zero volts, as measured at the high voltage side of the wind GSU."

This FERC requirement applies to all wind turbines in the United States (outside of Texas) except for those that meet the transition period requirements.[9]

41. ZVRT presents a more complex problem than LVRT. During a low voltage event, some grid information (e.g., frequency, phase, etc.) is still available during the event to provide information to a wind turbine's control system. Quite differently, during a zero voltage event, the wind turbine's control system is "blind," i.e., it cannot measure grid frequency and phase. In addition to large current spikes caused by the increased depth of a zero voltage fault, the inability of the generator's control system to track the grid during the fault presents the problem of maintaining synchronization when the grid recovers from the zero voltage fault. The loss of synchronism when the grid recovers can result in significant current spikes that can trip the turbine offline to avoid damage to the turbine.

F. Balance of Plant (BOP) Equipment

42. The grid codes discussed above permit the use of auxiliary equipment (often called balance of plant (BOP) equipment) to meet certain requirements. Appendix G of FERC Order 661-A states that "Wind generating plants may meet the LVRT requirements of this standard by performance of the generators or by installing additional equipment (e.g., Static VAr Compensator) within the wind generating plant or by a combination of generator performance

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[9] The transition period standard applies to wind generating plants subject to FERC Order 661 that have either: (i) interconnection agreements signed and filed with the Commission, filed with the Commission in unexecuted form, or filed with the Commission as non-conforming agreements between January 1, 2006 and December 31, 2006, with a scheduled in-service date no later than December 31, 2007, or (ii) wind generating turbines subject to a wind turbine procurement contract executed prior to December 31, 2005, for delivery through 2007.

and additional equipment." An example of this type of auxiliary equipment is a Dynamic VAR Compensator (DVAR). A DVAR can be installed at the wind farm substation and provides reactive power support to essentially shield the wind turbines from grid voltage disturbances. It is my opinion that utilizing such auxiliary equipment to satisfy ride through requirements with wind turbines that include a doubly-fed induction generator, such as the ones used in GE's 1.5 MW turbine and Mitsubishi 2.4 MW turbine, would be undesirable due to the significant cost of installing and maintaining such equipment and the fact that the wind turbine already includes sophisticated (and expensive) power electronics that could be used to deal with the problem. An additional disadvantage of using auxiliary equipment, such as a DVAR, to meet ride through requirements is that the entire wind farm is dependent on the operation of that auxiliary equipment. This of course assumes that such auxiliary equipment has actually been proven to provide zero voltage ride through capability.

V. LEGAL STANDARDS

43. I am not a lawyer, and do not intend to express any opinions about matters of law. Attorneys for GE have described to me the relevant law as it relates to the subject matter of this report. This section summarizes that description.

A. Claim Construction

44. I have been informed that the interpretation of the claims of a patent is a matter of law, to be decided by the Court. I understand that the parties have agreed on the meaning of certain claim terms, and disagreed about the meaning of others. I also understand that the Court has issued a claim construction decision concerning those disagreements. I have been asked to analyze the issue of infringement of the Asserted Claims of the '705 patent using the definitions agreed to by the parties and decided by the Court.

B. Infringement

45. I have been informed that whoever without authority makes, uses, offers to sell, or sells any patented invention during the term of a patent, infringes the patent. I have also been informed that a determination of infringement consists of two steps. The first is claim construction, which has already been undertaken by the Court and the parties. The second step in an infringement analysis is to compare the accused products or processes with the properly construed claims. A conclusion of infringement is proper if every limitation or step in an asserted claim is found in the accused product or process, either literally or under the doctrine of equivalents.

46. I have been informed that a party may be liable for contributory infringement it sells or offers to sell an apparatus for use in practicing a patented method, knowing that is especially adapted for infringing use and not a staple article or commodity of commerce suitable for substantial non-infringing use. I have also been informed that, for purposes of this inquiry, only the substantial non-infringing uses of the accused features are considered and not those of a product as a whole.

47. I have been informed that a party may also be liable for actively inducing infringement by others. A finding of induced infringement, like contributory infringement, requires a threshold finding of direct infringement.

VI. THE ‘705 PATENT

A. Overview

48. I have reviewed U.S. Patent No. 7,629,705 that was filed on October 20, 2006 and issued on December 8, 2009. The ‘705 patent is entitled “Method and Apparatus for Operating Electrical Machines. I have also reviewed the file history of the ‘705 patent.

49. The '705 patent describes a method and apparatus for providing voltage ride through capability in wind turbines, and in particular, zero voltage ride through (ZVRT). As explained in the Background of the Invention, grid voltage fluctuations often occur that can either damage a wind turbine or cause the wind turbine to trip offline. '705 Patent, col. 1:23-35. As explained in previous sections, severe voltage decreases that result in zero volts at the point of interconnection are particularly troublesome because the wind turbine loses visibility into the grid (as compared with voltage decreases where the wind turbine can still observe the grid). The '705 patent describes a method and apparatus for utilizing a control system to facilitate a wind turbine remaining connected to the grid during severe voltage decreases down to approximately zero volts, when the wind turbine is no longer able to observe the grid voltage.

50. The electrical machine illustrated in Figure 2 of the '705 Patent is a doubly-fed induction generator.[10] '705 Patent, col. 2:62-65. The generator stator (120) is directly connected to the electric power system. The generator rotor (122) is connected through a gearbox (114) to the rotor blade assembly. The spinning of the rotor blades causes the rotation of the rotor and the generation of electricity. Power conversion assembly (210) includes a rotor-side converter (220), a DC link (244), and a grid-side converter (222). Controller 202 senses conditions or operating characteristics of the wind turbine and controls the operation of the power conversion assembly. '705 Patent, col. 5:65-6:2. Specifically, the controller 202 is coupled in electronic data communication with a portion of the electrical machine (the power conversion assembly) to control the operation of the grid-side and rotor-side converters. '705

[10] The patent also discusses that a full conversion machine can be employed instead of the doubly-fed machine illustrated in Figure 2. '705 Patent, col. 3:48-55.

Patent, col. 4:9-11. This includes controlling active and reactive power, generator terminal voltage, and the rotor excitation current.

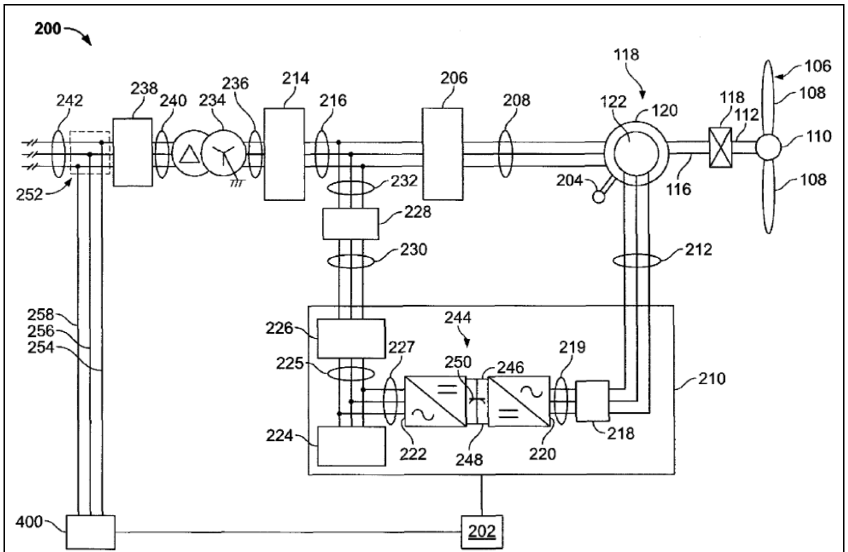


FIG. 2

51. Voltage fluctuations on the grid can create high rotor currents that may result in damage to the components in the power conversion assembly. '705 Patent, col. 6:47-55. The loss of output power caused by a grid voltage decrease can also create an acceleration of the generator potentially resulting in an over-speed trip. '705 Patent, col. 6:37-45. The '705 Patent specifically addresses the problem posed by zero voltage ride through (ZVRT), as compared with low voltage ride through (LVRT). '705 Patent, col. 6:63-67. A zero voltage event presents the additional difficulty of re-synchronizing quickly when the grid recovers because the grid is not visible to the controller during the voltage decrease. As discussed above, loss of synchronism while connected to the grid will result in large current spikes and subsequent tripping of the turbine. In order to facilitate ride through during zero voltage events, the '705 patent describes a control mechanism to facilitate remaining connected during and subsequent to a zero voltage fault. '705 Patent, col. 10:55-67.

52. Figure 4 illustrates an exemplary phase-locked loop regulator 400 that may be used with the electrical and control system 200. The objective of the PLL regulator is to track the frequency and phase of the grid voltage signal. '705 Patent, col. 8:64-67. The regulator includes a PLL (402), which includes a phase detection block (406) that generates a phase error signal by comparing grid voltage measurements with a PLL feedback signal. The phase error signal is then passed through the proportional-integral (PI) filter (410) and a PLL phase angle signal (450) is generated. The phase angle signal is used to control the power conversion assembly for subsequent control of currents injected into the rotor.

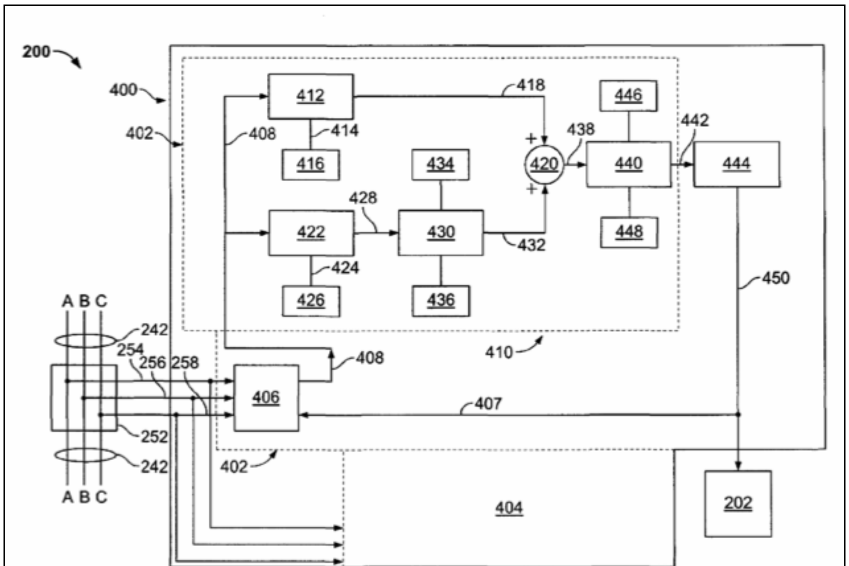


FIG. 4

53. In an exemplary embodiment, the PLL regulator includes a PLL state machine with exemplary gain and frequency limit values that is illustrated in Figures 5 and 6. '705 Patent, col. 8:47-49, col. 11:20-38. The PLL state machine facilitates managing gains and clamps of the PLL as a function of voltage characteristics of the grid. During a zero voltage event (i.e., when the grid voltage cannot be observed), the PLL state machine facilitates driving the PLL phase angle signal to a value that would be in effect if there was no grid disturbance and

further facilitates operating the PLL in a fixed-frequency mode. '705 Patent, col. 10:59-67. This control strategy prevents the PLL from "wandering" during a zero voltage event, and therefore, facilitates the wind turbine remaining connected during and subsequent to the zero voltage event.

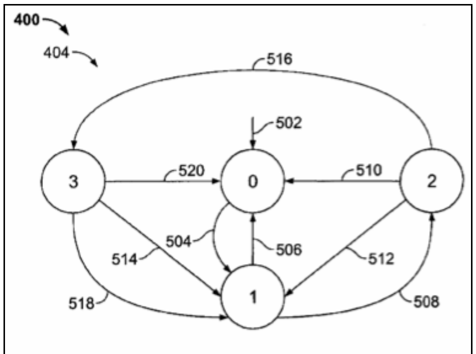


FIG. 5

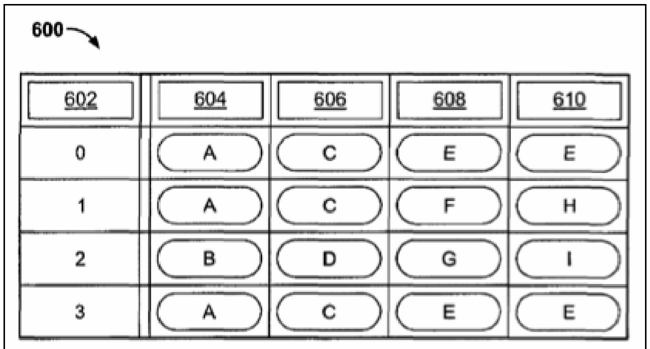


FIG. 6

54. The '705 Patent also explains that for voltage transients meeting certain conditions the controller may shutdown the power conversion assembly to mitigate electric power being channeled through the power conversion assembly. '705 Patent, col. 6:13-18.

B. Claim Construction

55. The table below lists the claim constructions adopted by the Court that I have applied in my analysis:

Claim Term	Court's Construction
"configuring the electrical machine such that the electrical machine remains electrically connected to the electric power system during and subsequent to a voltage amplitude of the electric power system operating outside of a predetermined range for an undetermined period of time" [claims 1, 9, 13]	setting up the electrical machine such that the electrical machine remains connected to the electric power system during and subsequent to the voltage amplitude operating outside of a defined range for an indeterminable or unknowable period of time

Claim Term	Court's Construction
"configuring the electrical machine and the control system such that the electrical machine remains electrically connected to the electric power system during and subsequent to the voltage amplitude of the electric power system decreasing below the predetermined range including approximately zero volts for the undetermined period of time, thereby facilitating zero voltage ride through (ZRVT)" [claim 1]	setting up the electrical machine and the control system such that the machine remains electrically connected to the electric power system during and subsequent to the voltage amplitude of the electric power system decreasing below the defined range, including approximately zero volts, for an indeterminable or unknowable period of time, thereby facilitating zero voltage ride through (ZVRT)

56. The table below lists the claim constructions agreed to by the parties that I have applied in my analysis:

Claim Term	Agreed Construction
"electrical machine" [claim 1]	a device that can convert mechanical energy to electrical energy or electrical energy to mechanical energy

C. GE's Wind Turbines

57. GE's 1.5 MW wind turbine is the most common wind turbine in ERCOT, representing 43% of the 11,000 installed wind MW in 2011. I have reviewed technical documentation associated with the 1.5 MW wind turbine and it is my opinion that the 1.5 MW wind turbines include zero voltage ride through capability and utilize the technology described and claimed in the '705 patent. GENDTX00099514-530 ("Grid Integration of GE 1.5 MW 60 Hz Wind Turbines"); GENDTX00010601-1075 ("Determination of the voltage dip capability of the GE 1.5 at Bexten, Germany").

58. The 1.5 MW turbine includes a doubly-fed induction generator and a converter control system that is coupled to the power grid and coupled in electronic data communication with the generator's power conversion system. The schematics for the converter control system illustrate that a control strategy is utilized in order to facilitate zero voltage ride through. Specifically, the converter control system utilizes the PLL state machine discussed above, which

is the preferred method disclosed in the '705 Patent. The following diagrams from the source code made available by GE illustrate the PLL regulator and the PLL state machine:

- V03.03.11C - July 21 2009\Doc\Diagrams\Line\LCL\Algorithm\ALG_045.vsd
- V03.03.11C - July 21 2009\Doc\Diagrams\Line\LCL\Protection\PROT_005.vsd

59. It is my understanding, based on information provided by the developer of the converter control code (Sidney Barker), that the state table shown in ALG_045 is the state table that is implemented in the source code, with the exception that the values shown in the two left-most columns are different from the values implemented in the code. The state diagram illustrates that the PLL is placed in a fixed frequency mode when the variable V.L_LineVShort = TRUE. This variable is set to TRUE when the voltage magnitude at the secondary (low voltage side) of the transformer remains less than 0.10 pu of nominal for over 5 ms.

VII. INFRINGEMENT

60. It is my opinion that Mitsubishi practices each step of claim 1 of the '705 patent when it installs and commissions its 2.4 MW wind turbines in the United States. The opinions in this report regarding Mitsubishi's 2.4 MW wind turbines apply to the following models that utilize the same generator and control system – MWT92, MWT95 and MWT100. Deposition of Hidekazu Ichinose, p. 32-33. It is my understanding that the difference between these models relates to the size of the blades. Deposition of Akira Yasugi, p. 83. The difference in the blade size is not material to the opinions contained in this report.

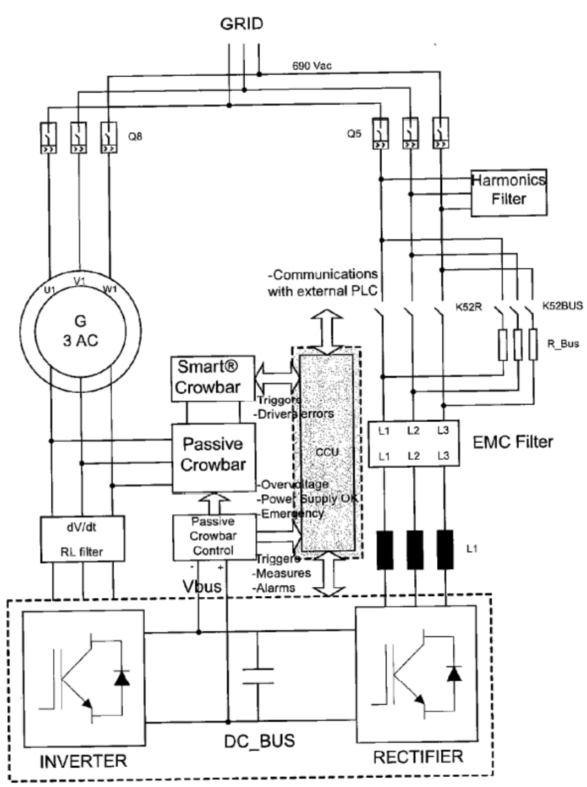
61. It is also my opinion that to the extent customers of Mitsubishi are installing and commissioning Mitsubishi Wind Turbines, that Mitsubishi is providing those customers with the essential components (generator and control system) for practicing each step of claim 1 of the '705 patent. These components, generator and control system, are specifically adapted to ride

through voltage decreases on the grid down to zero volts, and have no substantial non-infringing use because they must be configured in that manner in order to be used in the United States pursuant to FERC Order 661-A and ERCOT Operating Guide § 3.1.4.6.1.

62. The following sections include a description of Mitsubishi's 2.4 MW wind turbine (Section A), a description of relevant functionality in the Converter Control Unit of the 2.4 MW turbine (Section B), and a comparison of claim 1 of the '705 patent with the relevant aspects of the 2.4 MW turbine (Section C).

A. Mitsubishi's Wind Turbines

63. The 2.4 MW turbine utilizes a doubly-fed induction generator that produces 690 V AC at 60 Hz. The figure below (MHINDTX0000089) illustrates the control system of the DFIG in the 2.4 MW turbine.



Complete Control System of a doubly fed Generator

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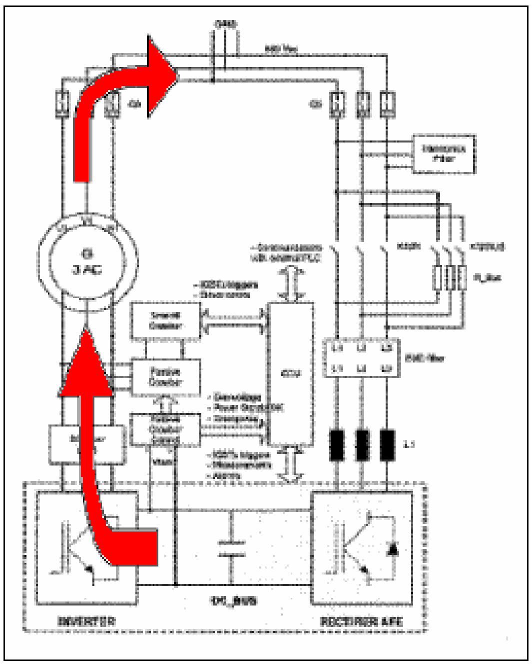
64. As shown in the figure above, there are two converters (called "Rectifier" and "Inverter") connected to a DC Bus. These converters are used to drive the rotor windings at the desired slip frequency, magnitude, and phase to properly synchronize the stator and provide power and voltage control. The converters are essentially identical because, depending on the operating state, power can be moved either into or out of the rotor (i.e., bidirectional). This is illustrated in the two figures below (color added). The converters are IGBT's, operating as three-phase bridges, whose switching is controlled by the Converter Control Unit (CCU).



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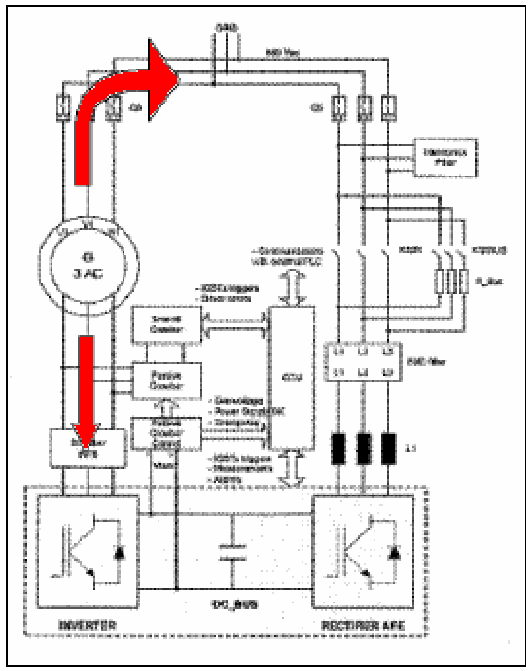

MPSANDTX002609

65. The CCU is a programmable device whose primary function is to manage and control the functioning of the Frequency Converter (i.e., Rectifier, Inverter, and DC Bus) in order to regulate power generation. The CCU also transmits and receives measurements, sends warning signals, and sends alarm signals.

66. The 2.4 MW turbine also includes a Smart Crowbar and a Passive Crowbar. The purpose of the Smart Crowbar is to short circuit the rotor via resistors during transients that can

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occur because of grid failures. *Smart Crowbar User Manual*, p 27 (MHINDTX0000454). The Smart Crowbar is controlled by the CCU and is engaged during certain types of grid voltage faults. The Passive Crowbar shorts the rotor in the event of a serious over-voltage (greater than 1325 V) in the DC Bus. *Ingeteam Training Summary for MWT-9x/2.4*, slide 4 (MPSANDTX0002592); *Passive Crowbar Manual*, p. 30 (MHINDTX0000389). Engaging the Passive Crowbar will trip the generator offline.

67. The control system of the 2.4 MW turbine also includes a PLC that is in communication with the CCU. The control system of the 2.4 MW is always in one of the following states: STOP, STAND-BY, START-UP, RUN, SHUTDOWN, DOWN WIND, DOWN WIND SOFT SUPPORT, MAINTENANCE, EMERGENCY, or GRID FAIL. These states are described in detail in the document "Safety Concept of MWT92/2.4" at pages 7-10 (MHINDTX0833286-323).

B. Converter Control Unit (CCU)

68. Mitsubishi and Ingeteam have made only one version of the source code for the CCU available for inspection (version O_be04_11). I have reviewed various portions of this source code version as well as discussed the source code with Michael Brogioli. It is my understanding that more recent versions of the CCU source code have not been produced (O_be10_00 and O_be10_10).[11]

69. A CCU Firmware Manual (IN00564-635) was produced with the source code version O_be04_11. Mitsubishi has also produced a version of the firmware manual

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[11] These source code versions are referenced in at least the following documents: IngSA001803-1814, IngSA001814-1841. On IngSA001812, it says that "Once the O_be10_00 firmware version has been validated following the tests described before, this firmware version should be installed on all wind turbines."

(MHINDTX00000293-359). These manuals are largely the same, with some slight variations. The citations in this report are to the version produced with the source code. The CCU Firmware Manual, which was created by Ingeteam, provides a high-level description of the CCU firmware, including a description of certain variables and parameters.

70. At least some of the operating states of the CCU are described in the CCU Firmware Manual. These operating states are listed in the table below with a description of the general functionality of the state:

Error	The CCU enters this mode in an emergency situation as a result of alarm detected by the CCU or because an emergency situation has been activated externally. To go from the error mode to the standby mode, the alarms generated need to be reset.
Standby	In this mode, the CCU waits for permission to enter the connection mode.
Equipment's Connections to the Mains	This mode starts the precharging of the DC Bus and is exited when the Bus Voltage Regulation mode is deactivated.
Bus Voltage Regulation	In this mode the DC Bus is gradually charged until the voltage reaches the desired setpoint.
Initial Pole Angle Test	This mode is used to determine the rotor's absolute position. This mode is only entered after exiting Error mode and is only done when the Bus Voltage Regulation mode is completed and the stator is disconnected.
Generator – Mains Synchronization	This mode is used to regulate stator voltage such that it's frequency, amplitude, and angle are equal to that of the grid.
Generator – Mains Coupling Logic	When synchronization is completed, coupling to the grid is enabled and the stator protection thermal magnetic switch is closed.
Generator – Stator Power Control	In this mode the generator is coupled to the grid and the stator power is regulated.

CCU Firmware Manual, pp. 3-9 (ING000567-573).

71. The CCU can transition from the Synchronization mode to the Stator Power Control mode if (i) the difference between the grid voltage angle and the stator voltage angle is less than 0.1 rad (**ThrDelay)**; (ii) the difference between the grid voltage frequency and the stator voltage frequency is less than 0.1 Hz (**ThrSlip)**; and (iii) the difference between effective grid voltage and the effective stator voltage has an absolute value of less than 10 V (**Thr_V_Ok)**. *CCU Firmware Manual*, pp. 7-8, 44, 54-55 (ING000571-572, 608, 618-619).

72. The figure below shows the waveforms of the grid voltage and the stator voltage during the process of normal synchronization. These data were captured at the Gulf Wind farm when the startup sequence was executed on Mitsubishi 2.4 MW turbines that had been installed with new CCU firmware. *Event Analysis in USA Wind Farms*, p. 10-19 (IngSA001823-1832).

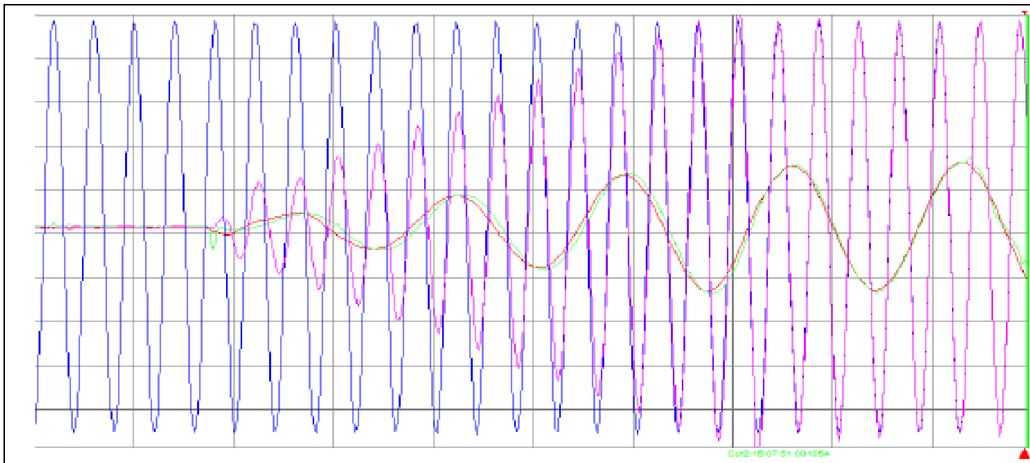

Figure: Grid Synchronization.

Blue: Grid R-S voltage Red: Inverter Phase R current Set Point Green: Inverter Phase R current Magenta: Stator R-S Voltage

As it can be seen in the register shown above, the inverter current set points are correctly tracked. The voltage regulated in the stator fits accurately to the voltage measured in the grid in voltage amplitude, phase and frequency.

73. The CCU is configured to generate a voltage failure alarm (**E_Vnet**) if the grid voltage is outside the boundaries indicated in the figure below from the CCU Firmware Manual. *CCU Firmware Manual*, p. 66 (ING000630) I have inserted the values (in red) of the parameters in the graph. These values are listed in the CCU Firmware Manual (ING000623-

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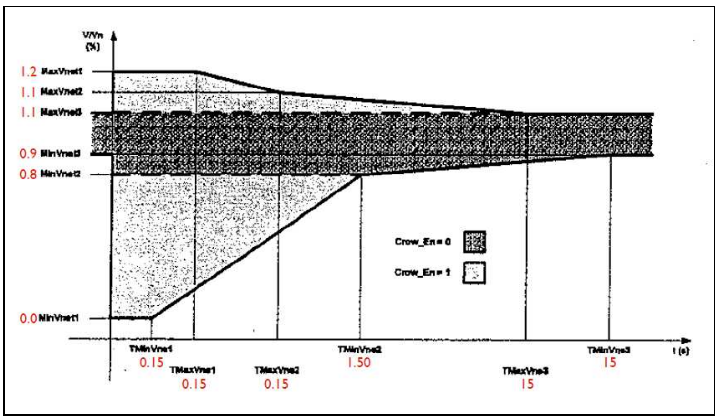
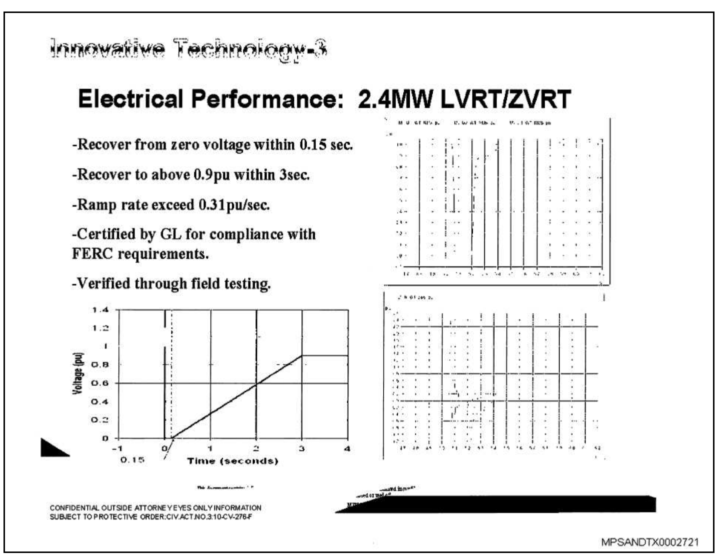
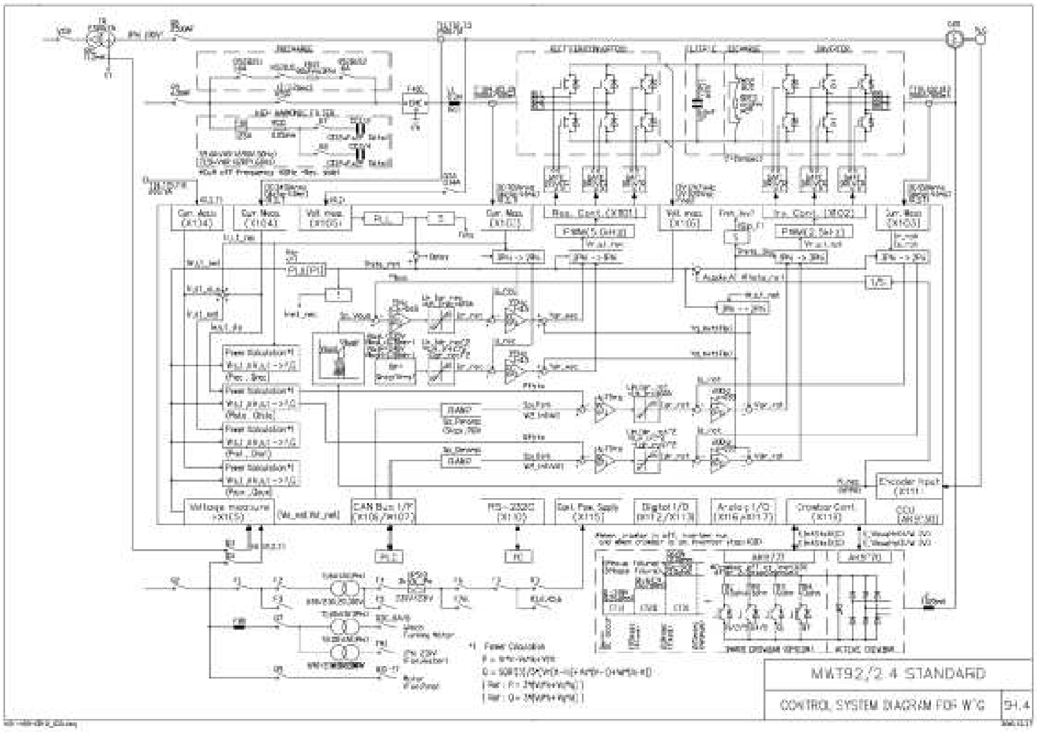
625) as well as in the source code (mensajes.h). When the E_Vnet flag is set, which means the grid voltage is outside of the grey shaded regions in the graph below, the generator will be disconnected from the grid. Deposition of Hidekazu Ichinose, p. 127-129. Accordingly, the CCU has been configured such that the DFIG will remain connected during and subsequent to decreases in the voltage amplitude of the power grid, including decreases down to approximately zero volts.



74. The slide below from a Mitsubishi presentation also illustrates the ride-through capability of the Mitsubishi 2.4 MW wind turbines and touts the "ZVRT" capability of the wind turbine.



75. The diagram copied below provides additional detail on the converter control system of the Mitsubishi 2.4 MW wind turbine.[12] *MWT92/2.4 Standard: Control System Diagram for WTG* (MHINDTX1033584 and IngSA005541).



76. The diagram illustrates PI controllers for the rotor-side inverter that are used to control the rotor injection currents that determine the active and reactive power output of the generator.[13] DFIG operation requires that the rotor injection currents have the desired slip

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[12] Ingeteam's witness explained that some portions of the schematic may not be accurate today, but confirmed that it represents the operation of the Mitsubishi machine. Deposition of Eneko Olea (10/7/2011), p. 61-62 (rough transcript).

[13] The PI controller is given target values for the process, e.g., voltage, and receives measurements of actual voltage. The "error" is the difference between measured voltage and target voltage. Given the error, the PI controller adjusts system parameters to drive the error to zero as quickly as possible without causing unnecessary overshoot. Tuning the PI integral time constant and proportional gain require intimate knowledge of the process being controlled.

frequency and proper phase angle relative to grid voltage so that the turbine generator's rotating internal voltage makes the generator appear to the grid as a steady-state synchronous generator with both power and voltage control. Relative phase angle between the internal voltage and the grid controls power flow, and rotor current magnitude controls voltage.

77. A PLL is shown to determine grid frequency (Fsta) and phase angle (Theta_net). The grid frequency is used to determine the slip frequency. The grid phase angle is necessary to transform three phase sinusoidal signals of voltage and current into phasor signals (called d-q transformation).[14] The control calculations are performed and the control signals are transformed back into three phase sinusoidal signals using the grid phase angle. Because the calculations are performed on phasors, which are referenced to the grid phase angle, an incorrect grid phase angle measurement will result in an incorrect control setting.[15]

78. Although the diagram shows the PLL determining the grid frequency (Fsta), Ingeteam documentation (IngSA005354-71) indicates that the CCU source code was modified sometime between July 2008 and January 2009 so that, in at least certain situations, slip is calculated using the nominal grid frequency (i.e., 60 Hz) instead of the grid frequency calculated by the PLL.

79. The CCU source code controls the operation Smart crowbar and activates the Smart Crowbar when the grid voltage drops below 0.1 p.u. The CCU instructs the Smart

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[14] Phasors are a short-hand notation for AC voltages and currents that was developed many years ago to simplify calculations in AC circuits. Phasors give the peak magnitude and phase angle of AC signals, leaving out the frequency term which is already known. The phase angle can be used to determine the time between peaks of the sinusoidal signals.

[15] Ingeteam's witness, Eneko Olea, confirmed that a measurement of the grid angle is necessary to correctly control the generator. Deposition of Eneko Olea (July 14), p. 104-107.

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Crowbar to remain engaged for 200 ms until after the grid recovers above 0.1 p.u. *Email from Ingeteam to Mitsubishi 8/27/2007* (IngSA005624-627); *Email from Ingeteam to Mitsubishi 9/13/2007* (IngSA005601-608); *Control System Specification of MWT95/2.4 Wind Turbine Generator (60 Hz) for Developing PSS/E Model*, p. 21 (IngSA001404-427).

80. In addition, when the grid voltage drops below 0.1 pu, the grid-side converter is switched off, which prevents channeling electric power through the power conversion assembly during the grid fault and grid recovery. *Email from Ingeteam to Mitsubishi 9/13/2007* (IngSA005601-608).

81. It is also my understanding based on reviewing Ingeteam documents (IngSA001608-638 at pp. 3-8, and IngSA001814-841 at pp. 3-5) that more recent versions of the CCU source code include modifications to the control system logic for purposes of improving the ride through behavior of the wind turbine. Specifically, IngSA001608-683, which is entitled "FERC Grid Code Compliance of Ingecon Wind MHI2500v2 with New FW Proposal," explains that the new control logic for implementing LVRT[16] has been programmed. The document does not explain the nature of the modifications but does state that the modifications are described in another document called "AS3380IFA10_MHI_ PROTECTED.pdf."[17] I have been

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[16] Ingeteam and Mitsubishi often use the term "LVRT" to include both LVRT and ZVRT. Specifically, the following Ingeteam documents use to term LVRT, but given the context it is clear that this capability includes ride through down to zero volts: IngSA001608-638, IngSA001803-813, and IngSA001814-841. For example, in IngSA001608-638, the use of "LVRT" clearly refers to both low and zero voltage ride through. This is shown in the diagram on IngSA001611, which illustrates that the wind turbines response to voltage dips includes remaining connected during and subsequent to zero voltage events that are not longer than 150 ms in duration.

[17] Ingeteam's witness could not remember any other documents aside from this pdf that describe the changes that were made to the code. Deposition of Eneko Olea (10/7/2011), p. 32 (rough transcript).

informed by attorneys for GE that this document has not been produced and therefore I have not been given the opportunity to review this document.

82. Another Ingeteam document (IngSA001814-841), dated May 23, 2011, explains that Ingeteam has analyzed information relating to grid faults that occurred at a wind farm in Texas that includes Mitsubishi 2.4 MW wind turbines. The analysis resulted in "modifications to improve the LVRT behavior of the turbine" that were programmed into the CCU source code and installed on turbines at the wind farm. IngSA001818. The firmware versions discussed in this document are labeled O_be10_00 and O_be10_10. As explained above, I have been informed that these two versions of the CCU firmware have not been produced by Ingeteam or Mitsubishi in this case.

83. In addition, IngSA001803-1813 says that "[t]he firmware version O_be10_10, generated from the O_be10_00 version, includes extra modifications to improve the LVRT behaviour of the wind turbines." IngSA001812. The document also says that "[o]nce O_be10_00 firmware version has been validated following the tests described before, this firmware version should be installed in all the wind turbines." IngSA001812.

84. It is my opinion that these documents (IngSA001608-638, IngSA001803-813, and IngSA001814-841), while not explaining the specific changes that were made to the CCU firmware, support my opinion that the CCU, which is a control system coupled in electronic data communication with the generator, has been configured such that the generator remains connected to the power grid during and subsequent to decreases in the voltage amplitude of the power grid, including decreases down to approximately zero volts. I reserve the right to supplement or modify the opinions in this report to extent additional documentation is made

available to me describing the changes made to the CCU firmware to improve ride through behavior of the Mitsubishi 2.4 MW wind turbines.

C. Claim 1 of the '705 Patent

85. Below is a table comparing the method of claim 1 with Mitsubishi's 2.4 MW wind turbine. In the left column of the claim chart, I have included the language of claim 1 and the constructions of the terms given by the Court or agreed to by the parties. The Court provided constructions for two entire paragraphs in claim 1. For ease of viewing, I have only inserted the portions of the Court's construction that modified the language in the claims.

Claim Language	Mitsubishi 2.4 MW Wind Turbine
1. A method for operating an electrical machine, said method comprising:	The Mitsubishi 2.4 MW wind turbine includes an electrical machine that is operated in the United States by Mitsubishi and its customers, including wind farms in Texas.

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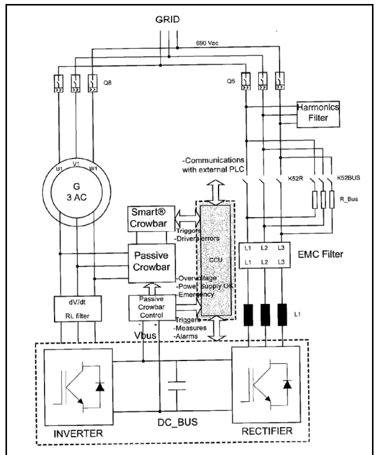
Claim Language	Mitsubishi 2.4 MW Wind Turbine
coupling the <u>electrical machine</u> [***a device that can convert mechanical energy to electrical energy or electrical energy to mechanical energy***] to an electric power system such that the electric power system is configured to transmit at least one phase of electric power to the electrical machine; and	The Mitsubishi 2.4 MW wind turbine includes a doubly-fed induction generator that includes a power conversion assembly. The DFIG is coupled to a three-phase electric power system (which is labeled "GRID" in the diagram below). A DFIG is an electrical machine that can convert mechanical energy into electrical energy. The DFIG is coupled to the grid during the installation and commissioning of the 2.4 MW wind turbine, which is supported and/or performed by Mitsubishi technical advisors. *Design Approval for MWT92/2.4 (50/60 Hz) Commissioning Manual* (MHINDTX0100000-32); Deposition of Akira Yasugi, p. 62-63.  Complete Control System of a doubly fed Generator The electric power system also transmits three phases of electric power to the electrical machine. This is shown in an Ingeteam Training Presentation (MPSANDTX0002586-2651). Electric power is transmitted to the DFIG to charge the DC Bus (MPSANDTX0002599-600) and electric power is consumed by the rotor in subsynchronous operation (MPSANDTX0002608).

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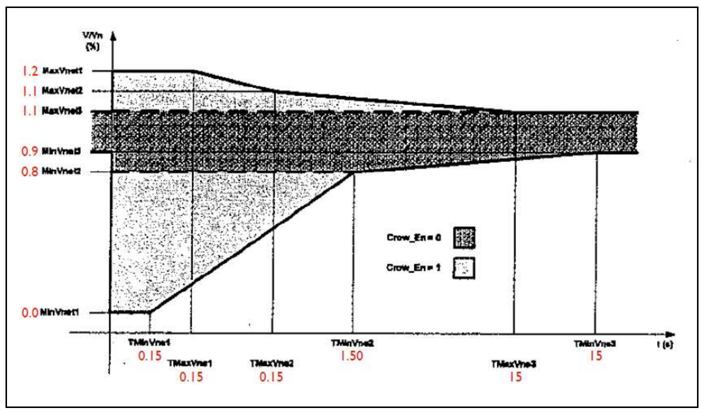
Claim Language	**Mitsubishi 2.4 MW Wind Turbine**
<u>configuring</u> [***setting up***] the electrical machine such that the electrical machine remains electrically connected to the electric power system during and subsequent to a voltage amplitude of the electric power system operating outside of a <u>predetermined range</u> [***defined range***] for an <u>undetermined period of time</u> [***indeterminable or unknowable period of time***], said configuring the electrical machine comprising:	The DFIG of the 2.4 MW wind turbine is configured to remain connected to the power grid during and subsequent to the voltage of the grid operating outside of a defined range for an unknowable period of time. The configuration facilitates both LVRT (low voltage ride through) and ZVRT (zero voltage ride through). The figure below from the CCU firmware manual illustrates the ride-through profile of the 2.4 MW wind turbine (red text added). The ride-through profile of the 2.4 MW turbine is also illustrated in a Mitsubishi presentation (MPSANDTX0002721). The profile illustrates that the DFIG will remain connected to the power grid when the voltage is outside of a defined range (below 0.9 p.u.) for an unknowable period of time that does not exceed 1.5 seconds.  The low and zero voltage ride-through capabilities of the 2.4 MW wind turbine have been verified through testing of actual equipment. Tests were performed on a MWT95/2.4 wind turbine located in Yokohama, Japan on September 2008 (MHINDTX2856334-408) and February 2009 (MHINDTX2879551-654). The September 2008 test included voltage dips with a residual voltage of 50%, 25%, and 0% for varying amounts of time. MHINDTX2856343. The results of each test case are shown on MHINDTX2856346-97. The February 2009 test included voltage dips with a residual voltage of 90%, 57.5%, 10%, and 0%. MHINDTX2879562. The results of each test case are shown on MHINDTX2879567-630.

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Claim Language	**Mitsubishi 2.4 MW Wind Turbine**
electrically coupling at least a portion of a control system to at least a portion of the electric power system;	The configuration of the DFIG to remain connected to the grid during and subsequent to grid voltage decreases includes coupling a control system to the electric power system. The converter control unit (CCU) is coupled to the power grid. Measurements of the three phases of the grid voltage are received via the X105 connector. *CCU User Manual*, p. 74 (MHINDTX0000061-170).
coupling the control system in electronic data communication with at least a portion of the electrical machine; and	The configuration of the DFIG to remain connected to the grid during and subsequent to grid voltage decreases includes coupling the control system in electronic data communication with the DFIG. The CCU is coupled in electronic data communication with at least a portion of the DFIG. The X101 and X102 fiber optic connectors are used to transmit control signals to and from the converters of the DFIG. *CCU User Manual*, p. 69-70 (MHINDTX0000061-170).

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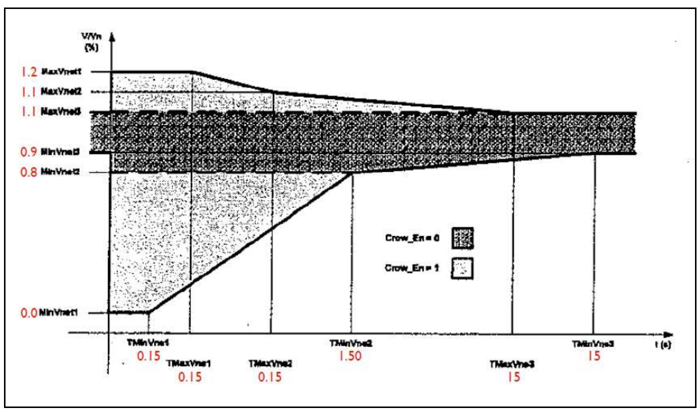
Claim Language	Mitsubishi 2.4 MW Wind Turbine
configuring [***setting up***] the electrical machine and the control system such that the electrical machine remains electrically connected to the electric power system during and subsequent to the voltage amplitude of the electric power system decreasing below the predetermined range [***defined range***] including approximately zero volts for the undetermined period of time [***indeterminable or unknowable period of time***], thereby facilitating zero voltage ride through (ZRVT).	The DFIG of the 2.4 MW wind turbine is configured to remain connected to the power grid during and subsequent to the voltage of the grid operating outside of a defined range, including zero volts, for an unknowable period of time. The configuration facilitates ZVRT (zero voltage ride through) as shown in a Mitsubishi presentation (MPSANDTX0002721). The figure below from the CCU firmware manual illustrates the zero-voltage ride through profile of the 2.4 MW wind turbine (red text added). The profile shows that the DFIG will remain connected to the power grid during zero voltage grid disturbances of unknown duration that do not exceed 150 ms. An Ingeteam document discussing the occurrence of voltage drops at Texas wind farms notes that "when a fault occurs in a real system, the instant at which the voltage is recovered is not controlled, and could happen at any time in a period." *22nd October 2009 Event Analysis in Penascal and Gulf Wind Farms (TEXAS-USA)*, p. 18 (IngSA001297-1326).  As discussed above in Section VII.B, the CCU includes control logic that facilitates the doubly-fed induction generator remaining connected to the power grid during grid voltage decreases, including decreases down to approximately zero volts that do not exceed 150 ms in duration. The zero ride-through capabilities of the 2.4 MW wind turbine has been verified through testing of actual equipment. Tests were performed on a MWT95/2.4 wind turbine located in Yokohama, Japan on September 2008 (MHINDTX2856334-408) and February 2009 (MHINDTX2879551-654). Both the September 2008 and February 2009 tests show that the 2.4 MW machine is configured to remain connected during and subsequent to zero voltage events of varying duration.

86. If necessary, I may wish to issue a supplement to this report, including, for example to opine on information made available to me after the date of this report. I reserve the right to modify or supplement my opinions as appropriate.

Date: 10/18/2011

W. Mack Grady

EXHIBIT A

LIST OF MATERIALS CONSIDERED

Mitsubishi / Ingeteam Documents:

Converter Control Unit (CCU) User Manual	MHINDTX0000061-170
Frequency Converter Module User Manual	MHINDTX0000171-292
Firmware for AK9729 CCU – User Manual	MHINDTX0000293-359
Firmware for AK9729 CCU (MWT9x.v2, AC) – User Manual	ING000564-635
Passive Crowbar User Manual	MHINDTX0000360-427
Smart Crowbar User Manual	MHINDTX0000428-525
Ingecon Wind 2520 kW – Instruction, Commissioning and Maintenance Manual	MHINDTX0000536-826
Training Course MWT9X.v2	MHINDTX0027302-407
LVRT and ZVRT Diagrams	MHINDTX0078764-766
Design Approval for MWT92/2.4 (50/60 Hz) Commissioning Manual	MHINDTX0100000-32
Design Approval for MWT92/2.4 – Safety Concept of MWT92/2.4	MHINDTX0833826-323
MWT92/2.4 Standard – Control System Diagram for WTG	MHINDTX1033584
Determination of the voltage dip capability of the MWT95/2.4 at Yokohama, Japan	MHINDTX2856334-408
Determination of the voltage dip capability of the MWT95/2.4 according to FERC order 661-A	MHINDTX2879551-654
Determination of the voltage dip capability of the MWT95/2.4 according to FERC order 661-A	EDISON_MISSION_0000524-535
Certification Report – Wind Turbine Mitsubishi MWT95/2.4, 50 Hz	EDISON_MISSION_0000560-563
Ingeteam Training Summary for MWT-9x/2.4	MPSANDTX0002586-651
Mitsubishi Wind Turbine (presentation)	MPSANDTX0002707-755
Preliminary Estimate relating to LVRT Verification (November 27, 2006)	MHINDTX0013608-612 (translation)
Email dated 9/18/2006	MHINDTX0385866-867 (translation
Email dated 8/31/2006	MHINDTX0928815-816
Shop Test Report of MHI 2.5 MW Prototype	IngSA000020-95
INGECON Wind Converter 2.5 mW – Smart Crowbar Report	IngSA000760-777
Smart Crowbar Analysis – Low Voltage Ride Through Behaviour of Ingecon Wind MHI2500 with RC Circuit Installed on Smart Crowbar	IngsA001058-126
Smart Crowbar Analysis – Smart Crowbar OV Protection Analysis (Varsistors → RC Circuit)	IngSA001127-139
Smart Crowbar Analysis – Low Voltage Ride Through Behaviour of Ingecon MHI2500 with Reduced DC Bus Voltage Strategy	IngSA001172-203

22nd October 2009 Event Analysis in Penascal & Gulf Wind Farms (TEXAS-USA) – Technical & Management Document	IngSA001272-296
22nd October 2009 Event Analysis in Penascal & Gulf Wind Farms (TEXAS-USA) – Technical Document	IngSA001297-326
Control System Specification of MWT95/2.4 Wind Turbine Generator (60 Hz) for Developing PSS/E Model	IngSA001404-427
Test Plan – MWT92/2.4, Yokohama	IngSA001444-453
Low Voltage Ride Through – Technical Document – Low Voltage Ride through Behaviour of Ingecon Wind MHI2500v2	IngSA001454-528
FERC Grid Code Compliance of Ingecon Wind MHI2500v2 with New FW Proposal – Technical Document	IngSA001608-638
Ride Through Capability of Ingecon Wind Converters – Technical Information – Ingecon Wind DFIG Converter's Behaviour in Grid Fault Conditions	IngSA001740-747
Ingeteam Countermeasure and Power Converter Analysis Proposal – Technical Report	IngSA001803-813
Event Analysis in USA Wind Farms – Technical Assistance to Gulf Wind (May-2011) Technical Report	IngSA001814-841
Untitled Diagram	IngSA001875
Firmware of CCU versions Lp(x), M, Mp(x) – Description of Software Revisions AK9732, AK9733	IngSA005354-371
Untitled Diagram	IngSA005400
Ingecon-Wind 2500 kW Training Document	IngSA005443-531
Untitled Diagrams	IngSA005532-534
Untitled Diagrams	IngSA005537-538
Untitled Diagrams	IngSA005539-540
MWT92/2.4 Standard – Control System Wiring Diagram for WTG	IngSA005541
Untitled Diagram	IngSA005585
Email chain dated 9/13/2007	IngSA005601-608
Email chain dated 8/27/2007	IngSA005624-627
Email chain dated 5/13/2009	IngSA005657-664
Email chain dated 10/1/2006	IngSA005702-703
Email dated 9/13/2006	IngSA005704
Pending Item List	IngSA005867
U.S. Patent No. 7,939,954	
P200930586 (translation)	
INV_REG.asm (source code file from O_be04_11)	
INV_CAL.asm (source code file from O_be04_11)	
MENSAJES.h (source code file from O_be04_11)	
GESTOR_M.asm (source code file from O_be04_11)	
GESTOR_S.asm (source code file from O_be04_11)	
TARE1_M.asm (source code file from O_be04_11)	
TAREA1_S.asm (source code file from O_be04_11)	

MAIN_M.c (source code file from O_be04_11)	
MAIN_S.c (source code file from O_be04_11)	

GE documents:

U.S. Patent No. 7,629,705	
File History of U.S. Patent No. 7,629,705	
Grid Integration of GE 1.5 MW 60 Hz Wind Turbines	GENDTX00099514-530
Determination of the voltage dip capability of the GE 1.5 at Bexten, Germany	GENDTX00010601-1075
ALG_045.vsd (V03.03.11C)	
PROT_005.vsd (V03.03.11C)	
Wind Power Plant Performance	GENDTX00070979-982
Converter Control Concepts to meet Severe Grid Requirements with GE 1.5MW Wind Turbine Generators	GENDTX00049302-328
Schematics dated 11/10/2005	GENDTX00022049-58
LVRT Test in Bexten Germany	GENDTX00006205-241
ZVRT Report for V02.00.01C Release	GENDTX00049620-626
Zero Voltage Ride-through Converter Shutdown Decision Leading up to Wind-DFIG V02.00.01C Release	GENDTX00099562-563

Deposition Transcripts:

Deposition of Hideakazu Ichinose (4/11-12/2011)	
Deposition of Takatoshi Matsushita (4/7-8/2011)	
Deposition of Akira Yasugi (4/13/2011)	
Deposition of Eneko Olea (7/14-15/2011, 10/7/2011)	
Deposition of Einar Larsen (5/5/2011)	
Deposition of Anthony Klodowski (6/7/2011)	
Deposition of Sidney Barker (6/7/2011)	
Deposition of John D'Atre (6/10/2011)	
Deposition of Goran Drobjnak (7/12/2011)	

Other Documents:

Judge Furgeson Claim Construction Order (5/9/2011)	
ERCOT Operating Guide (November 1, 2009)	
FERC Order 661	
FERC Order 661-A	
Brochures from American Superconductor website	
E.ON, Grid Code, High and extra high voltage (August 1, 2003)	
E.ON, Supplemental Network Connection Rules for Wind Energy Systems (December 1, 2001)	

Request for Inter Partes Reexamination of U.S. Patent No. 7,629,705	
U.S. Patent and Trademark Office, Decision Granting Inter Partes Reexamination and Office Action in Inter Partes Reexamination	
J.F. Manwell, J.G. McGowan, A.L. Rogers, Wind Energy Explained: Theory, Design, and Application," John Wiley & Sons, 2003	
G. M. Masters, Renewable and Efficient Electric Power Systems, John Wiley & Sons, 2004.	
Andreas Petersson, Analysis, Modeling and Control of Doubly-Fed Induction Generators for Wind Turbines, PhD Thesis, Chalmers University of Technology, Goteborg, Sweden, 2005.	
C. D. Le, Fault Ride-Through of Wind Parks with Induction Generators, MS Thesis, Chalmers University of Technology, Goteborg, Sweden, 2009	
P. M. Anderson, Anjan Bose, "Stability Simulation of Wind Turbine Systems," Paper 83 SM 328-2, IEEE-PES 1983 Summer Meeting.	
I. Erlich, H. Wrede, C. Feltes, "Dynamic Behavior of DFIG-Based Wind Turbines During Grid Faults," IEEE 1-4244-0844-X, 2007.	
J. Soens, K. de Brabandere, J. Driesen, R. Belmans, "Doubly Fed Induction Machine: Operating Regions and Dynamic Simulation," ISBN 90-75815-07-7, EPE 2003, Toulouse, 2003.	
N. Miller, J. Sanchez-Gasca, W. Price, R. Delmerico, "Dynamic Modeling of GE 1.5 and 3.6 MW Wind Turbine-Generators for Stability Simulations," IEEE WTG Modeling Panel Session, July 2003.	
R. Piwko, N. Miller, J. Sanchez-Gasca, X. Yuan, R. Dai, J. Lyons, "Integrating Large Wind Farms into Weak Power Grids with Long Transmission Lines," IEEE-PES T&D Conference & Exposition, Dalian, China, 2005.	
R. Zavadil, N. Miller, A. Ellis, E. Muljadi, "Making Connections," IEEE Power & Energy Magazine, Nov./Dec. 2005.	
E. Muljadi, C. Butterfield, B. Parsons, A. Ellis, "Effect of Variable Speed Wind Turbine Generator on Stability of a Weak Grid, IEEE Trans. on Energy Conversion, March 2007.	
J. Tande, E. Muljadi, et.al., "Dynamic models of wind farms for power system studies – status by IEA Wind R&D Annex 21," EWEC'04, London, U.K., Nov. 2004.	

Keith Case, California ISO Memorandum on “Decision on Interconnection Requirements Reform for Renewable Resources,” May 10, 2010.	
E. Muljadi, C. Butterfield, J. Conto, K. Donohoo, “Ride-Through Capability Predictions for Wind Power Plants in the ERCOT Network,” IEEE PES General Meeting, San Francisco, June 2005.	
Michael Grable, “ERCOT Wind Experience,” FERC Technical Conference on Integrating Renewable Resources into the Wholesale Electric Grid, March 2, 2009.	
C. Quist, et.al., Wind Generation Task Force (WGTF), “The Technical Basis for the New WECC Voltage Ride-Through (VRT) Standard,” June 13, 2007.	
FERC Standard Large Generator Interconnection Agreement (LGIA), Order No. 2003-C.	

EXHIBIT B

Grady, Oct. 18, 2011

The University of Texas at Austin
Department of ECE
Faculty Personnel Record

Full name: William Mack Grady
Title: Professor and Jack S. Josey Centennial Professor in Energy Resources
Department: ECE
Date and Place of Birth: January 1950, Waco, Texas
Citizenship: USA
Education: The University of Texas at Arlington, BS(EE), 1971
Purdue University, MS(EE), 1973
Purdue University, PhD(EE), 1983
Professional Registration: Texas Professional Engineer #48629
Current and Previous Academic Positions:
The University of Texas at Arlington, Assistant Professor Part-time 1978–79
The University of Texas at Austin, Assistant Professor of ECE 1983–86
The University of Texas at Austin, Associate Professor of ECE 1986–92
The University of Texas at Austin, Professor of ECE, since 1992
Other Professional Experience:
Texas Power and Light Company (now Oncor), Dallas. System Planning Engineer, 1974-80.
Recent Consulting:
Electric Power Research Institute, Knoxville, TN.
Scientific Applications and Research Associates (SARA) for DOD Defense Threat Reduction Agency, electric grid-related projects
Office of the Attorney General, Consumer Protection & Public Health Division, Austin, TX
GE Wind Energy
Honors and Awards:
IEEE Fellow, 2000, for "Contributions in the Analyses and Control of Power System Harmonics and Power Quality."
Faculty Appreciation Award, Student Engineering Council, College of Engineering, U.T. Austin, November 2001
Annual Faculty Appreciation Award, "for fostering the well-being and professional development of engineering graduate students," U.T. Austin Graduate Engineering Council, Fall 2004.
Annual ECE Student Body Teaching Award, U.T. Austin ECE Dept., Fall 2004.
Annual Gordon Lepley Teaching Award, U.T Austin ECE Dept., Fall 2004.
Annual Texas Exes Teaching Award for the College of Engineering, U.T. Austin, Spring 2005 and Spring 2007.
IEEE Favorite Professor, U.T. Austin Student Chapter, 2005.
Student Engineering Council Award, Faculty Appreciation Week, Spring 2006.
U.T. Austin College of Engineering, Women's Advocate Award, Spring 2007.
Memberships in Professional and Honorary Societies:
Eta Kappa Nu
Tau Beta Pi
IEEE, Fellow, 2000, "For contributions to the analysis and control of power system harmonics and electric power quality"
IEEE Power and Energy Society, since 1972
IEEE Student Chapter of the Power Engineering Society, U.T. Austin Faculty Advisor since inception in 2006
Texas Solar Energy Society
Texas Renewable Energy Industries Association
Departmental Assignments and Contributions:
Graduate Advisor, 1986–88

Graduate Studies Committee, Member 1983–present, Chairman 1988–1990
Budget Council Member, 1992-present
Strategic Faculty Hiring Committee Chairman, 2004–2008
Chairman's Privy Council, 2004–2010
Associate Chairman, 2004–2010
Head of the Energy Systems Area, since mid-1980's
Regular speaker at ECE Tech Night
Sponsors several senior lab teams each semester, usually in solar topics

University Assignments:

Advisory committee for selecting members of the Academy of Distinguished Teachers, 2005–2007.
U.T. Explore (open house exposition), ECE Coordinator, 2001–2003, regular sponsor of "Power Bike" exhibit.
Honors Colloquium, regular speaker to high school students each summer.
Educational Policy Committee, since 2009

IEEE Power and Energy Society:

Transmission and Distribution Committee, Chairman, 2005–2006.
Working Group on Power System Harmonics, Chairman, 1985–1994.
General Systems Subcommittee, Chairman, 1995–1998.
IEEE-PES Transmission and Distribution Conference and Exposition, Dallas, Technical Program Chair, 2003
IEEE International Conference on Harmonics and Quality of Power (ICHQP): Steering Committee Member, since 1987.

Continuing Education and Community Activities (year 2000 and later):

U.T. Austin Workshops
Texas Electric Power Workshop Co-Chairman, Spring 2000.
Electric Power Quality and Reliability Workshop Co-Chairman, Fall 2003.
Renewable Energy Workshop Co-Chairman, Fall 2004, 2006, 2007.
The Intelligent Utility Co-Chairman, Spring 2007
U.T. Austin Short Courses (organized through CLEE)
Fundamentals of Electric Power Systems Organizer, June 2005-2007.
Electric Power Quality and Harmonics Organizer, June 2005-2006.
Edison Lecture Series, ECE Dept., "Renewable Energy," Faculty Organizer and Speaker, January 2007.
Texas Annual Renewable Energy Roundup, Fredericksburg, Guest Speaker on Renewable Energy Topics, 2007, 2008, 2010

Federal Agencies

DOE, 2010 Solar Programs Peer Reviewer, Washington, D.C., May 2010
FBI, Advisor on Critical Infrastructure, since 2010
DOD, Secret Security Clearance, since 2008

Publications:

Refereed Archival Journal Publications

(with G.T. Heydt), A Matrix Method for Optimal VAR Siting, IEEE Trans. on Power Apparatus and Systems, PAS-94 (4), 1214-1222, July/August 1975.

(with G.T. Heydt), Rapid Methods for Transmission Tower Structural Analysis and Design, IEEE Trans. on Power Apparatus and Systems, PAS-94 (4), 1223-1231, July/August 1975.

(with R.R. Shoults and S. Helmick), An Efficient Method for Computing Loss Formula Coefficients Based Upon the Method of Least Squares, IEEE Trans. on Power Apparatus and Systems, PAS-98 (6), 2144-2151, November/December 1979.

(with R.R. Shoults, S.K. Chang and S. Helmick), A Practical Approach to Unit Commitment, Economic Dispatch and Savings Allocation for Multiple-Area Pool Operation with Import/Export Constraints, IEEE Trans. on Power Apparatus and Systems, PAS-99 (2), 625-635, March/April 1980.

(with W.N. Song and G.T. Heydt), The Integration of HVDC Subsystems into the Harmonic Power Flow Algorithm, IEEE Trans. on Power Apparatus and Systems, PAS-103 (8), 1953-1961, August 1984.

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(with W.L. Taylor), Correction of Phase Voltage Measurements Referenced to an Ungrounded Neutral, IEEE Trans. on Power Apparatus and Systems, PAS-104 (7), 1757-1760, July 1985.

(with G.T. Heydt), Determination of Harmonics in an AC Power System Caused by HVDC Converters, Electric Machines and Power Systems, 10 (1), 39-52, 1985.

(with M.S. Hwang and H.W. Sanders), Distribution Transformer Winding Losses Due to Nonsinusoidal Currents, IEEE Trans. on Power Delivery, PWRD-2 (1), 140-146, January 1987.

(with M.S. Hwang and H.W. Sanders), Calculation of Winding Temperatures in Distribution Transformers Subjected to Harmonic Currents, IEEE Trans. on Power Delivery, 3(3), 1074-1079, July 1988.

(with Q.C. Lu and M.M. Crawford), An Adaptive Algorithm for Short-Term Multinode Load Forecasting in Power Systems, IEEE Trans. on Circuits and Systems, 35(8), 1004-1010, August 1988.

(with Q.C. Lu, M.M. Crawford and G.M. Anderson), An Adaptive Nonlinear Predictor with Orthogonal Escalator Structure for Short-Term Load Forecasting, IEEE Trans. on Power Systems, 4(1), 158-164, February 1989.

(with A.H. Noyola and G.L. Viviani), An Optimized Procedure for Determining Incremental Heat Rate Characteristics, IEEE Trans. on Power Systems, 5(2), 376-383, May 1990.

(with J. Farach and S.D. Kellogg), A Linearized Procedure for Voltage Control, Electric Power System Research, 18, 11-18, 1990.

(with M.J. Samotyj, A.H. Noyola), Survey of Active Power Line Conditioning Methodologies, IEEE Trans. on Power Delivery, 5(3), 1536-1542, July 1990.

(with R.E. Rice, W.G. Lesso, A. H. Noyola, M. E. Connolly), Power Generation Scheduling Through the Use of Generalized Network Flow Programming, IEE Proceedings - C: Generation, Transmission and Distribution, 138(1), 39-46, January 1991.

(with E. G. Preston), An Efficient Method for Calculating Power System Production Cost and Reliability, IEE Proceedings - C: Generation, Transmission and Distribution, 138(3), 221-227, May 1991.

(with M.J. Samotyj, A.H. Noyola), Minimizing Network Harmonic Voltage Distortion with an Active Power Line Conditioner, IEEE Trans. on Power Delivery, 6(4), 1690-1697, October 1991.

(with L. A. Groce, T. M. Huebner, Q. C. Lu, M. M. Crawford), Enhancement, Implementation, and Performance of an Adaptive Short-Term Load Forecasting Algorithm, IEEE Trans. on Power Systems, 6(4), 1404-1410, November 1991.

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Taekhyun Kim; Powers, E.J.; Grady, W.M.; Arapostathis, A.; , "Detection of Flicker Caused by Interharmonics," *Instrumentation and Measurement, IEEE Transactions on* , vol.58, no.1, pp.152-160, Jan. 2009

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Rylander, M.; Grady, W.M.; Arapostathis, A.; Powers, E.J.; "Power Electronic Transient Load Model for Use in Stability Studies of Electric Power Grids," Power Systems, IEEE Transactions on , vol.25, no.2, pp.914-921, May 2010

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Power Quality Implications of Overcompensated Systems, EPRI Power Quality Applications (PQA) 2003 North American Conference and Exposition, Monterey, California, June 2-4, 2003.

(with Marek Waclawiak), Predicting Voltage Sags at Customer Locations with Substation-Only Measurements, EPRI Power Quality Applications (PQA) 2003 North American Conference and Exposition, Monterey, California, June 2003.

(with Y. Shin, A. Monti, F. Ponci, A. Arapostathis, E. J. Powers, R. Dougal), Virtual Power Quality Analysis for Ship Power System Design, Proc. of the 21st IEEE Instrumentation and Measurement Technology Conference (IMTC 2004), Como, Italy, 1758-1763, May 2004.

(with Byungchul Jang, Changyong Shin, E.J. Powers), Machine Fault Detection Using Bicoherence Spectra, Proc. of the 21st IEEE Instrumentation and Measurement Technology Conference (IMTC 2004), Como, Italy, 1661-1666, May 2004.

(with M.A.S. Masoum, A. Jafarian, M. Ladjevari, E.F. Fuchs), Fuzzy Approach for Optimal Placement and Sizing of Capacitor Banks in the Presence of Harmonics, Proc. of the IEEE PES General Meeting, Denver, June 2004.

(with S. Santoso), Developing an Upper-Level Undergraduate Course on Renewable Energy and Power Systems, Proc. of the IEEE PES General Meeting, San Francisco, 1239 – 1243, June 2005.

(with J. Carroll; K.C. Nagaraj; A. Arapostathis, E.J. Powers), Dynamic Reconfiguration Preserving Stability, Proc. of the IEEE Electric Ship Technologies Symposium, ESTS 2005, Philadelphia, 105-107, July 2005.

(with T. Kim, E.J. Powers; A. Arapostathis), Real and Reactive Power Analysis for Interharmonics, Proc. of the IEEE Electric Ship Technologies Symposium, ESTS 2005, Philadelphia, 244 - 247, July 2005.

(with G. Tilte, E.J. Powers, A. Arapostathis; J. Lobry), Introduction of the Concept of Friendliness Power to Characterize the Harmonic Emission of Nonlinear Loads, Proc. of the IEEE Electric Ship Technologies Symposium, ESTS 2005, Philadelphia, 306 - 312, July 2005.

(with M. Rylander; A. Arapostathis; E.J. Powers), A Voltage Sag-Based Procedure for Determining Transient Stability Models of Conventional Loads, Proc. of the IEEE Electric Ship Technologies Symposium, ESTS 2005, Philadelphia, 321 - 324, July 2005.

(with M. Rylander, A. Arapostathis, and E. J. Powers), Analyzing Voltage Sags to Determine Daily and Seasonal Variations in Transient Stability Load Models, Proc. 8th International Conference on Electrical Power Quality and Utilisation (EPQU' 05), Krakow, Poland, 359-363, September 2005.

(with M. Vatani, A. Arapostathis), A Voltage-Only Method for Estimating the Location of Transmission Faults, Proc. 8th International Conference on Electrical Power Quality and Utilisation (EPQU' 05), Krakow, Poland, 515-521, September 2005.

(with Taekhyun Kim, Edward J. Powers, and Ari Arapostathis,) "Robust Interharmonic Detection in Adjustable Speed Drives Using Cross Bicoherence," Proceedings of the 12th IEEE International Conference on Harmonics and Quality of Power (ICHQP'06), Cascais, Portugal, October 2006.

(with Taekhyun Kim, Adam Wang, Edward J. Powers, and Ari Arapostathis), "Detection of Flicker Caused by High-frequency Interharmonics," IEEE Instrumentation and Measurement Technology Conference (IMTC'07), Warsaw, Poland, May 2007.

(with Taeihyun Kim, E. J. Powers, A. Arapostathis), "A Novel QPC Detector for the Health Monitoring of Rotating Machines," IEEE Instrumentation and Measurement Technology Conference (IMTC'07), Warsaw, Poland, May 2007.

(with Keerthi C. Nagaraj, Johnson Carroll, Thomas Rosenwinkel, Ari Arapostathis, and Edward J. Powers), Perspectives on Power System Reconfiguration for Shipboard Applications, Proceedings of the IEEE Electric Ship Technologies Symposium, Arlington, VA, May 2007.

(with Taekhyun Kim, Wonjin Cho, Edward J. Powers, and Ari Arapostathis), ASD System Condition Monitoring Using Cross Biocherence, Proceedings of the IEEE Electric Ship Technologies Symposium, Arlington, VA, May 2007.

(with Matthew Rylander, Ari Arapostathis, and Edward Powers), Enhancement and Application of a Voltage Sag Station to Test Transient Load Response, Proceedings of the IEEE Electric Ship Technologies Symposium, Arlington, VA, May 2007.

(with H. Park, B. Jang; E. J. Powers, A. Arapostathis), "Machine Condition Monitoring Utilizing a Novel Bispectral Change Detection, IEEE Power Engineering Society General Meeting, June 2007

(with Mehrdad Vatani and Ari Arapostathis), "A New Fault Location Method for Electric Power Grids," Summer Simulation Multiconference (SummerSim'07), Society for Modeling and Simulation International (SCS), San Diego, CA, July 2007.

Hyeonsu Park; Powers, E.J.; Grady, W.M.; Arapostathis, A.; Condition Monitoring Based on Estimating Complex Coupling Coefficients," *Instrumentation and Measurement Technology Conference Proceedings, 2008. IMTC 2008. IEEE* , vol., no., pp.781-786, 12-15 May 2008

Taekhyun Kim; M. Rylander, E. J. Powers, W. M. Grady, A. Arapostathis, LED Lamp Flicker Caused by Interharmonics, Instrumentation and Measurement Technology Conference Proceedings, 2008, 12-15 May 2008, pp. 1920 - 1925

Ha Thu Le; Santoso, S.; Grady, W.M.; , "Development and analysis of an ESS-based application for regulating wind farm power output variation," *Power & Energy Society General Meeting, 2009. PES '09. IEEE* , vol., no., pp.1-8, 26-30 July 2009

Kulkarni, S.; Allen, A.; Santoso, S.; Grady, W.M.; , "Phasor measurement unit placement Algorithm," Power & Energy Society General Meeting, 2009. PES '09. IEEE , vol., no., pp.1-6, 26-30 July 2009

Grady, W.M.; Costello, D.; , "Implementation and application of an independent Texas synchrophasor network," Protective Relay Engineers, 2010 63rd Annual Conference for , vol., no., pp.1-12, March 29 2010-April 1 2010

Rylander, Matthew; Grady, W. Mack; , "Problems in the use of Norton equivalent models for single-phase nonlinear loads," Power and Energy Society General Meeting, 2010 IEEE , vol., no., pp.1-7, 25-29 July 2010

(with David Costello), "Implementation and Application of an Independent Texas Synchrophasor Network," Western Protective Relay Conference, Spokane, WA, Oct. 20, 2010.

(with Joon Kim), "Synchrophasor Analysis of 221 Generating Unit Trips in ERCOT," IEEE Power and Energy Society General Meeting, Detroit, July 2011.

Other Major Publications (2000 and later)

Notes for Short Course on Fundamentals of Electric Power Systems, U.T. Austin CLEE, Austin, Texas, June 2006.

Notes for Short Course on Electric Power Quality and Harmonics, U.T. Austin CLEE, Austin, Texas, June 2006.

(with J. Carroll, K. Nagari, T. Rosenwinkel, A. Arapostathis, and E.J. Powers), "Stability and Switching, Conwise Systems, Reconfiguration," Electric Ship Research and Development Consortium Workshop on Simulation Based Design for Electric Warships, Tallahassee, FL, February 14-15, 2006, February 2006

(with M. Rylander, A. Arapostathis, and E. Powers), "Methods for Extracting Stability Load Models from Data Collected from Voltage Sags," Electric Ship Research and Development Consortium Workshop on Simulation Based Design for Electric War Ships, Tallahassee, FL, February 14-15, 2006 , February 2006

(with E. J. Powers, and A. Arapostathis), "Interharmonic Effects on the Power Quality of Shipboard Power Systems," Electric Ship Research and Development Consortium Meeting, Columbia, SC, May 31 - June 1, 2006, May 2006

(with A. Arapostathis and E.J. Powers), "Health Monitoring and Querying of Sensors," presented at the Electric Ship Research and Development Consortium Meeting, Columbia, SC, May 31 - June 1, 2006, May 2006

(with Surya Santoso), Observations From the Texas Synchrophasor Network, http://users.ece.utexas.edu/~grady, timely updates, since Feb. 2009.

Technical Reports (2000 and later)

(with A. Mansoor, B. Fortenbery, A. Von Jouanne), Power Quality Mitigation Technology Demonstration at Industrial Customer Sites, Industrial and Utility Harmonic Mitigation Guidelines and Case Studies, TR1000566, EPRI, Palo Alto, CA November 2000.

(with J. Chung, Y. Shin, A. Parsons, E. Powers), Application of Advanced Signal Processing Techniques to Power Quality Analysis, TR1001161, EPRI, Palo Alto, CA December 2000.

(with J. A. Pappas), SSP Technology Investigation of a High-Voltage DC-DC Converter, Final Report for Contract NAS3-00135, NASA Glenn Research Center, Cleveland, OH, May 2001.

(with A. Wright and A. Mansoor), Enhancing the Value of Power Quality Monitoring Data, EPRI-PEAC Report 1001657, Palo Alto, CA, February 2003.

(with B. Johnson, C. Perry, and A. Mansoor), Power Quality Implications for Overcompensated Systems, EPRI-PEAC Report 1001683, Palo Alto, CA, February 2003.

(with A. Mansoor), The Potential Effects of Single-Phase Power Electronic-Based Loads on Power System Distortion and Losses, Volume 1: Current Harmonics Produced by Distributed Single-Phase Power Electronic Loads, EPRI-PEAC Report 1000654, Palo Alto, CA, September 2003.

(with E. Fuchs, D. Lin, T. Stensland), The Potential Effects of Single-Phase Power Electronic-Based Loads on Power System Distortion and Losses, Volume 2: Single-Phase Transformers and Induction Motors, EPRI-PEAC Report 1000655, Palo Alto, CA, September 2003.

(with T. Batan, D. Yildirim, E. Fuchs), The Potential Effects of Single-Phase Power Electronic-Based Loads on Power System Distortion and Losses, Volume 3: Real-Time Monitoring and Calculation of the Derating of Single-Phase Transformers Under Non-Sinusoidal Operation, EPRI-PEAC Report 1000662, Palo Alto, CA, September 2003.

(with P. T. Staats, A. Arapostathis), The Potential Effects of Single-Phase Power Electronic-Based Loads on Power System Distortion and Losses, Volume 4: The Harmonic Impact of Electric Vehicle Battery Charging, EPRI-PEAC Report 1000664, Palo Alto, CA, September 2003.

(with P. T. Staats), The Potential Effects of Single-Phase Power Electronic-Based Loads on Power System Distortion and Losses, Volume 5: Considerations Related to Neutral-to-Earth Voltage, EPRI-PEAC Report 1000665, Palo Alto, CA, September 2003.

Oral Presentations (2000 and later):

Professional Society Presentations

(with J. Billo and J. Carroll), Reconfigurable Power Systems, IEEE - PES Central Texas Chapter Meeting, Austin, TX, July 22, 2003

Observations from the Texas Synchrophasor Network, Breaking News Session, IEEE-PES Annual Meeting, July 26, 2010, Minneapolis, MN

Invited Lectures

Considerations in Predicting, Modeling, and Improving Harmonic Levels in Commercial and Industrial Facilities, EPRI Power Quality Interest Group Meeting, April 26, 2000, Kansas City, Missouri.

Power System Harmonics, Reliant Energy HL&P, November 2, 2000 (one full day), Ft. Worth, Texas

Power System Harmonics, TXU Electric & Gas, November 9th and 21st, 2000 (two full days), Ft. Worth, Texas

Automatic Location of Switched Capacitors in Distribution Systems, EPRI-PEAC Power Quality Interest Group Meeting, October 24-25, 2000, Knoxville, TN.

Future Research Topics in Electric Power Quality, NSF/DOE/EPRI Sponsored Workshop on Future Research Directions for Complex Interactive Electric Networks, November 16-17, 2000, Washington, D.C.

Assessing PQ Levels From a Limited Set of Monitoring Data, EPRI Distribution and Power Quality Product Line Meeting, Phoenix, Arizona, October 2, 2001.

Power System Engineering Topics: Symmetrical Components and Fault Calculations, TXU Electric & Gas, August 6th and August 20th, 2002 (two full days), Ft. Worth, Texas

Voltage Sag Transformation Field Verification Update, EPRI Power Quality Product Line Meeting, Phoenix, Arizona, September 30, 2002.

Power Quality Implications of Overcompensated Distribution Systems, EPRI Power Quality Product Line Meeting, Phoenix, Arizona, September 30, 2002.

A Review of Symmetrical Components and Fault Calculation Formulas, 56th Annual Conference for Protective Relay Engineers, Texas A&M University, College, Station, TX, April 8, 2003.

The Energy Systems Area, U.T. Austin, ECE Dept., Eta Kappa Nu Tech Night, Spring 2003.

Modeling Power System Transients Using ATP, PowerGrid, Singapore, December 2003 (three day short course).

Renewable Energy and Grid Issues, 2005 Engineers for a Sustainable World Conference, U.T. Austin, October 6, 2005.

Introduction to Renewable Energy, Edison Lecture Series, ECE Dept., U.T. Austin, January 2007.

Renewable Energy in the U.S, Norway – U.S. Offshore Forum, U.S. Department of Commerce, Houston, April 27, 2007.

A Comprehensive on the Impact of Power Electronic Loads on Power System Transient Response and Stability, 2007 NSF ECCS Grantees' Workshop to Broaden Participation, Reno, NV, May 2007.

EE362L Power Electronics Lab, Faculty Innovation Seminar, College of Engineering, U.T. Austin, Sept. 2007.

Observations from the Texas Synchrophasor Network, Schweitzer Engineering Labs I44 Conference, Branson, MO, August 19, 2010.

Lessons Learned from the Texas Synchrophasor Network, Workshop on Active Power Control from Wind Power, sponsored by NREL and EPRI, Boulder, CO, January 27, 2011.

Lessons Learned from the Texas Synchrophasor Network, Conference for Protective Relay Engineers, College Station, TX, April 2011.

Lessons Learned from the Texas Synchrophasor Network, Utility Wind Integration Group (UWIG), Kansas City, MO, April 2011.

Lessons Learned from the Texas Synchrophasor Network, IEEE Fort Worth Section, Fort Worth, TX, May 2011.

Lessons Learned from the Texas Synchrophasor Network, North American Synchrophasor Initiative (NASPI), Toronto, June 2011.

Patents:
(with Alexander McEachern), Harmonic-Adjusted Power Factor Meter, U.S. Patent Numbers 5,212,441 (May 18, 1993), 5,298,855 and 5,298,856 (March 29, 1994), 5,302,890 (April 12, 1994).

(with R. Chan, G. C-Y Chung, D. Gerez, W. B. Leuschner, G. P. Olson), Voltage Sag/Swell Testing Station, 5,886,429, March 23, 1999.

(with Antony Parsons, Edward Powers, Surya Santoso, John Soward), "System and Method for Locating a Disturbance in a Power System Based Upon Disturbance Power and Energy," 6,360,178 (March 19, 2002), 6,772,075 (August 3, 2004), and 6,996,483 (February 7, 2006).

Software (available on http://users.ece.utexas.edu/~grady/)
PCFLO: loadflow, short circuit, and harmonics analysis.
ABC012: phase sequence calculator with phasor diagrams.
Wind Dancer: Tracks ERCOT wind generation and grid parameters

Grants and Contracts:
Assessment of Winding Losses in Transformers Due to Harmonic Currents, The University of Texas at Austin Center for Energy Studies, $20,000, September 1, 1983 - August 31, 1985.

Development of a Power System Harmonic Model for Gaseous Discharge Lighting, The University of Texas at Austin Bureau of Engineering Research, $3,000, February 13, 1984 - August 31, 1985.

Modeling of Power System Harmonics, Texas Power and Light Company, $16,814, June 1, 1984 - September 30, 1984.

Equipment Donation from Square D Company, $11,000, August 1984.

Development of a Microprocessor Based Voltage Distortion Analyzer for Electric Power Systems, The University of Texas at Austin University Research Institute, $4,825, October 16, 1984 - August 31, 1985.

Monetary Donation for Graduate Research in Power System Engineering, Central and Southwest Services, Inc., $2,000, December 1984.

Enhancement of Harmonic Power Flow Studies, Purdue Research Foundation (Subcontract of Electric Power Research Institute RP2444-1), $56,100, June 1, 1985 - April 30, 1986.

Investigation of Harmonic Related Problems, Texas Power and Light Company, $32,000, November 1, 1985 - December 31, 1988.

Solving the Optimal Power Flow Program with Network Flow Programming, The University of Texas at Austin University Research Institute Summer Research Award, $9,000, June 1, 1986 - August 31, 1986.

Real Time Fuel Cost Minimization for Electric Power Pools, CRAY Research, Inc., $33,689, April 1, 1986 - December 31, 1986.

Real-Time Fuel Cost Minimization and Security Analysis for Electric Power Pools, CRAY Research, Inc., $33,689, January 1, 1987 - May 15, 1988.

Adaptive Short-Term Load Forecasting in Power Systems, The University of Texas at Austin University Research Institute Grant, $3,500, January 1 - August 31, 1988.

Survey of Active Power Line Conditioning Methodologies, Electric Power Research Institute, $54,688, February 22, 1988 - December 31, 1989.

Identification of Harmonic Sources, U.T. Center for Energy Studies, $3,649, September 1, 1988 - August 31, 1989.

Improvement of End-Use Electric Power Quality through the use of Active Power Line Conditioners, State of Texas Energy Research in Applications Program (ERAP), $161,690, March 1, 1989 - February 29, 1992.

Adaptive One-Week-Ahead Electric Load Forecasting, TU Electric Company, $46,999, June 1, 1989 - December 31, 1991.

Enhancements of HARMFLO and Demonstration in a Utility Environment, TU Electric Company, $51,682, June 1, 1989 - December 31, 1991.

Modeling of Power System Harmonics Using HARMFLO, U.S. Department of Energy, Bonneville Power Administration, $74,900, June 16, 1989 - August 31, 1992.

Short-Term Load Forecasting, U.T. Center for Energy Studies, $12,522, September 1, 1989 - August 31, 1990.

Survey of Active Power Line Conditioning Methodologies (continued), Electric Power Research Institute, $99,990, January 1, 1990 - December 31, 1991.

Block Travel Grant to Attend IEEE International Conference on Power System Harmonics (in Budapest, Hungary, October 1990), National Science Foundation, $800.

Applied Research to Assist the Staff of the Public Utility Commission of Texas, Public Utility Commission of Texas, $51,160, February 1, 1991 - August 31, 1991.

Preliminary Power Quality Modeling and Simulation, Electrotek Concepts, Inc., (Subcontract of Electric Power Research Institute RP3098-1), $55,000, September 1, 1990 - August 31, 1992.

Advanced Electrical System Design for Future Navy Surface Combatants, Teledyne Inet (a division of Teledyne Industries, Inc.), $35,000, October 8, 1991 - October 8, 1992.

(with A. Arapostathis), Optimized Placement of Instrumentation for Locating Sources of Power System Harmonics, State of Texas Advanced Research Program (ARP), $123,305, November 1, 1991 - November 1, 1993.

The Potential Effects of Single-Phase Electronic-Based Loads on Power System Distortion and Losses, Electric Power Research Institute, $221,914, January 1, 1993 - June 30, 1995.

Equipment Donation from Square D Power Logic, Harmonics Monitoring Equipment, $16,169, November 1994.

Development of a Power Quality Testing Station, Houston Lighting & Power, $49,969, January 1, 1995 - December 31, 1999.

Predicting the Net Harmonic Currents Produced by Commercial Facilities," Delmarva Power, $39,959, June 1, 1995 - December 31, 1999.

The Potential Effects of Single-Phase Electronic-Based Loads on Power System Distortion and Losses, Electric Power Research Institute, $25,000, (continued) July 1, 1995 - October 31, 1995.

The Potential Effects of Single Phase Electronic-Based Loads on Power System Distortion and Losses, Electric Power Research Institute, Project WO4887-01, $158,000, August 1, 1995 - December 31, 1996.

(with E. J. Powers), Automatic Identification of Electric Power Quality Disturbances, Texas Higher Education Coordinating Board ATP, $149,000, January 1, 1996 - December 31, 1997.

(with E. J. Powers), Wavelet-Based Neural Classifier for PQ Disturbances, Electric Power Research Institute, Project WO4941-8, $133,164, January 1, 1997 - December 31, 1997.

(with E. J. Powers), Wavelet-Based Recognition System for High-Voltage Transmission Line Disturbances, Texas Higher Education Coordinating Board ATP, $128,057, January 1, 1998 - December 31, 1999.

(with E. J. Powers), Impact of Wavelet Theory on Power Quality, Electric Power Research Institute, Project WO8214-01, $75,000, April 15, 1998 - December 31, 1998.

The Potential Effects of Single Phase Electronic-Based Loads on Power System Distortion and Losses, Electric Power Research Institute, Project WO4887-01, $79,000, October 1, 1998 - December 31, 1999 (continued).

(with E. J. Powers), Wavelet-Based Recognition System for High-Voltage Transmission Line Disturbances, TU Electric (supplemental funding for Texas Higher Education Coordinating Board ATP Project 003658-092), $45,000, January 1, 1999 - December 31, 2000.

Gift for Research in Electric Power Quality, TU Electric, $8,500, December 1998.

Gift for Support of Undergraduate Power Engineering Laboratory Projects, TU Electric, $4,000, December 1998.

(with E. J. Powers), Impact of Wavelet Theory on Power Quality, Electric Power Research Institute, Project WO8214-01, $40,000, April 15, 1999 - December 31, 1999 (continued).

(with E. J. Powers), Impact of Wavelet Theory on Power Quality, Electric Power Research Institute, Project WO8214-01, $99,800, June 1, 2000 - December 31, 2000 (continued).

(with R. Hebner), Improved Inductive Loop Design for High-Bed and Light Vehicles, Texas Department of Transportation (TxDOT), $124,598, September 1, 2000 – August 31, 2001.

Gift for Support of Undergraduate Power Engineering Laboratory Projects, TXU Electric & Gas, $10,000, December 2000.

(with R. Hebner), Improved Inductive Loop Design for High-Bed and Light Vehicles, Texas Department of Transportation (TxDOT), (continued), $168,206, September 1, 2001 – August 31, 2002.

(with E. J. Powers and A. Arapostathis), ONR Electric Ship Program, Office of Naval Research, $163,300, June 1, 2002 – May 31, 2007.

(with E. J. Powers and A. Arapostathis), ONR Electric Ship Program, Office of Naval Research, $128,331, (continued), December 1, 2002 – May 31, 2003.

(with E. J. Powers and A. Arapostathis), ONR Electric Ship Program, Office of Naval Research, $163,260, (continued), March 1, 2003 – December 12, 2003.

(with E. J. Powers and A. Arapostathis), ONR Electric Ship Program, Office of Naval Research, $329,200, (continued), January 1, 2004 – December 31, 2004.

(with A. Arapostathis), A Comprehensive Study on the Impact of Power Electronic Loads on Power System Transient Response and Stability, National Science Foundation, ECS-0424169, ($38,146 for first year), September 1, 2004 – August 31, 2005.

(with E. J. Powers and A. Arapostathis), ONR Electric Ship Program, Office of Naval Research, $410,000, (continued), November 1, 2004 – October 31, 2005.

(with A. Arapostathis), A Comprehensive Study on the Impact of Power Electronic Loads on Power System Transient Response and Stability, National Science Foundation, ECS-0424169, ($41,831 for second year), September 1, 2005 – August 31, 2006.

(with E. J. Powers and A. Arapostathis), ONR Electric Ship Program, Office of Naval Research, $478,000, (continued), November 1, 2005 – October 31, 2006.

(with E. J. Powers and A. Arapostathis), ONR Electric Ship Program, Office of Naval Research, $353,652, (continued), November 1, 2006 – October 31, 2007.

Assessing the Performance of Photovoltaic Installations in the Austin Energy System, $45,000, July 1, 2007 – June 30, 2008. (Year 1)

(with E. J. Powers and A. Arapostathis), ONR Electric Ship Program, Office of Naval Research, $257,338, November 1, 2007 – August 31, 2008.

(with Surya Santoso) Evaluating the Potential Benefits of Synchronized Voltage Phase Angle Measurements in ERCOT, Texas Emerging Technology Fund, through the Center for the Commercialization of Electric Technologies, $126,420, January 2008 – January 2009.

Assessing the Performance of Photovoltaic Installations in the Austin Energy System, $45,000, July 1, 2008 – June 30, 2009. (Year 2)

(with Surya Santoso), Applying Synchrophasor Technology to Enable the Integration of Intermittent Renewable Generation into Electric Power Grids, Electric Power Research Institute, EP-P32175/C14942, $99,000, January – December 2009. (Year 1)

Assessing the Performance of Photovoltaic Installations in the Austin Energy System, $45,000, July 1, 2009 – June 30, 2010. (Year 3)

Applying Synchrophasor Technology to Enable the Integration of Intermittent Renewable Generation into Electric Power Grids, Electric Power Research Institute, EP-P32175/C14942, $99,000, January – December 2010. (Year 2)

Assessing the Performance of Photovoltaic Installations in the Austin Energy System, $45,000, July 1, 2010 – June 30, 2011. (Year 4)

Field Verification of High-Penetration Levels of PV into the Distribution Grid with Advanced Power Conditioning Systems, DOE through Virginia Polytechnic Institute and State University, DE-EE0002062, $80,000, January – December 31, 2010. (Year 1)

(with Surya Santoso), Generator Frequency Response Preliminary Analysis, Electric Power Research Institute, $25,000, Fall 2010.

Applying Synchrophasor Technology to Enable the Integration of Intermittent Renewable Generation into Electric Power Grids, Electric Power Research Institute, EP-P32175/C14942, $100,412, January – December 2011. (Year 3)

Field Verification of High-Penetration Levels of PV into the Distribution Grid with Advanced Power Conditioning Systems, DOE through Virginia Polytechnic Institute and State University, DE-EE0002062, $75,000, January – December 31, 2011. (Year 2)

Assessing the Performance of Photovoltaic Installations in the Austin Energy System, $45,000, Oct. 1, 2011 – Sept. 30, 2012. (Year 5)

Courses Taught (2000 and later):

Spring 2000, Power Electronics, EE362L (14753) and EE394 (15023) combined
Fall 2000, Power System Engineering II, EE394J (15580) and EE369 (15345), combined
Fall 2000, Introduction to ECE, EE302, (14625 and 14630, combined)
Spring 2001, Power Electronics, EE362L (14740) and EE394 (15065) combined
Spring 2001, Circuit Theory, EE411 (14135 and 14140, combined)
Fall 2001, Introduction to ECE, EE302, (14675 and 14680, combined)
Fall 2001, Power Quality and Harmonics, EE394, Topic 9 (15710) and EE379K (15515), combined
Spring 2002, Power Electronics and Laboratory, EE362L (14870) and EE394 (15215), combined. Note – the course was expanded to include a lab.
Fall 2002, Introduction to ECE, EE302, (14930 and 14935, combined)
Fall 2002, Electrical Transients in Power Systems, EE394J, 16025.
Spring 2003, Electric Power Transmission and Distribution, EE368 (14905) and EE394J (15095), combined
Spring 2003, Power Electronics and Laboratory, EE362L (14815) and EE394 (15085), combined.
Fall 2003, Circuit Theory, EE411 (14638 and 14639, combined)
Spring 2004, Electric Power Transmission and Distribution, EE368 (14835) and EE394J (15080), combined
Spring 2004, Power Electronics and Laboratory, EE362L (14745) and EE394 (15070), combined.
Summer 2004, Power Electronics and Laboratory, EE362L (76930) and EE394 (76935), combined.
Fall 2004, Circuit Theory, EE411 (15285 and 15290, combined)
Fall 2004, Power System Engineering, EE369 (15975) and Power System Engineering II, EE394J-2, (16240), combined
Spring 2005, Power Electronics and Laboratory, EE362L (15300 and 15302) and EE394 (15655), combined
Summer 2005, Power Electronics and Laboratory, EE362L (77235 and 77240) and EE394 (77290), combined
Fall 2005, Power Electronics and Laboratory, EE362L (16126, 16127, 16128) and EE394 (16442 and 16443), combined
Spring 2006, Power Electronics and Laboratory, EE362L (16126, 16127, 16128) and EE394 (16442 and 16443), combined
Spring 2006, Electric Power Transmission and Distribution ,EE368, (15770) and EE394J (16030), combined
Fall 2006, Power Electronics and Laboratory, EE362L (16625, 16630, 16640)

and EE394 (17015 and 17020), combined
Spring 2007, Power Electronics and Laboratory, EE362L (16175, 16180, 16185, 16190) and EE394 (16515, 16520, 16525, 16530), combined
Summer 2007, EE411, Circuit Theory (77255)
Fall 2007, EE362L and EE394, Power Electronics and Laboratory (16940, 17385, 16945, 17390, 16950, 17395, 16955, 17400)
Fall 2007, EE411, Circuit Theory (16385 and 16390)
Spring 2008, EE394, Topic 14, Electrical Transients in Power Systems (16765)
Fall 2008, EE362L and EE394, Power Electronics and Laboratory (16920, 17345, 16925, 17350, 16930, 17355, 16935, 17360)
Fall 2008, EE379K, Renewable Energy and Power Systems (17115)
Spring 2009, EE394J-2 Power System Engineering II (16845)
Fall 2009, EE362L and EE394, Power Electronics and Laboratory (16885, 16890, 16895, 17310, 16900, 17315)
Fall 2009, EE411, Circuit Theory (16345, 16350)
Spring 2010, EE394J-2 Power System Engineering II (16930)
Fall 2010, EE462L and EE394, Power Electronics and Laboratory (16705, 17050, 16710, 17055, 16715, 17060)
Fall 2010, EE362R, Renewable Energy and Power Systems (17115)
Spring 2011, EE394J-2, Power System Engineering II (17155)
Fall 2011, EE462L and EE394, Power Electronics and Laboratory
Fall 2011, EE411, Circuit Theory

Ph.D. Supervisions Completed:

Min-sh Davis Hwang, 1985, ECE
Roy E. Rice, (with W.G. Lesso),1986, Mechanical Engineering
Qing C. Lu (with M.M. Crawford), 1988, ECE
Antonio H. Noyola, 1991, ECE
Jose E. Farach, (with A. Arapostathis), 1992, ECE
Wen-Kung Gary Chang, August 1994, ECE
Arshad Mansoor, December 1994, ECE
Brion Cornett (with R. D. Marshall), December 1995, ECE
Ahsan Chowdhury, August 1996, ECE
Trent Staats (with A. Arapostathis), May 1997, ECE
Eugene Preston (with M. L. Baughman), May 1997, ECE
Antony Parsons, August 1999, ECE
Jiseong Kim (with A. Arapostathis), May 2000, ECE
Inyoung Suh, May 2000, ECE
Wan K. Ham (with M. L. Baughman), May 2003, ECE
Mark Flynn, August 2003, ECE
Yong June Shin (with E. J. Powers), August 2004, ECE
Mehrdad Vatani, December 2006, ECE
Matthew Rylander, 2008, ECE
Virat Kapur, 2009, ECE

M.S. Supervisions Completed:

Hani A. Khatib, 1986, ECE
Jose E. Farach, 1987, ECE
Antonio H. Noyola, 1987, ECE
Ricardo Chan, 1987, ECE
Ali-Reza Payravi, 1988, ECE
Gary M. Anderson, 1988, ECE
Barbara H. Kenny, 1988, ECE

Ahsan Chowdhury, 1992, ECE
Shelly Kochhar, 1992, ECE
Arshad Mansoor, 1992, ECE
Kaiser Ahmed, 1992, ECE
Pierre Hubert (with A. Arapostathis), 1993, ECE
Kaly Srinivasan, 1993, ECE
Sameer Verma, 1993, ECE
Gregorio Chung, 1994, ECE
Shih-Yih Lai, 1994, ECE
Trent Staats, 1994, ECE
Asif Jakwani, 1994, ECE
Frederic Gorgette, December 1995, ECE
Antony Parsons, December 1996, ECE
Jiseong Kim, May 1997, ECE
Mark Flynn, August 1999, ECE
Mehrdad Vatani, May 2001, ECE
Vincent Petit, December 2001, ECE
Aparna Chavali, May 2002, ECE
Samrat Data, August 2002, ECE
Charles Foldes, May 2003, ECE
Virat Kapur, May 2003, ECE
Jeff Billo, December 2003, ECE
Gordon Lyssy, December 2003, ECE
John Moseley, December 2003, ECE
Anitha Sampath, December 2004, ECE
Karthik Byreddy, May 2005, ECE
Clayton Stice, May 2006, ECE
Matthew Rylander, May 2006, ECE
Harsha Viswanathan, May 2007, ECE
Sangyoun Kim, May 2007, ECE
Lori Domaschk, May 2008, ECE
Rossen Tsartzev, May 2009, ECE
Moses Kai, May 2009, ECE
Kevin Jiang, December 2009, ECE
Puja Kowley, May 2010, ECE
Joon Hyun Kim, May 2010, ECE
Niveditha Reddy, May 2010, ECE
Will Lovelace, May 2010, ECE
Alex Rangel, May 2011, ECE
Deepak Mohan, August 2011, ECE

Ph.D. in Progress:

A. Students Admitted to Candidacy
Moses Kai

B. Post M.S. Students preparing to take Ph.D. qualifying exam
Joon Kim
John Moseley
Rossen Tsartzev

M.S. in Progress:
Aprajita Sant